ASTRONOMY

April 1981
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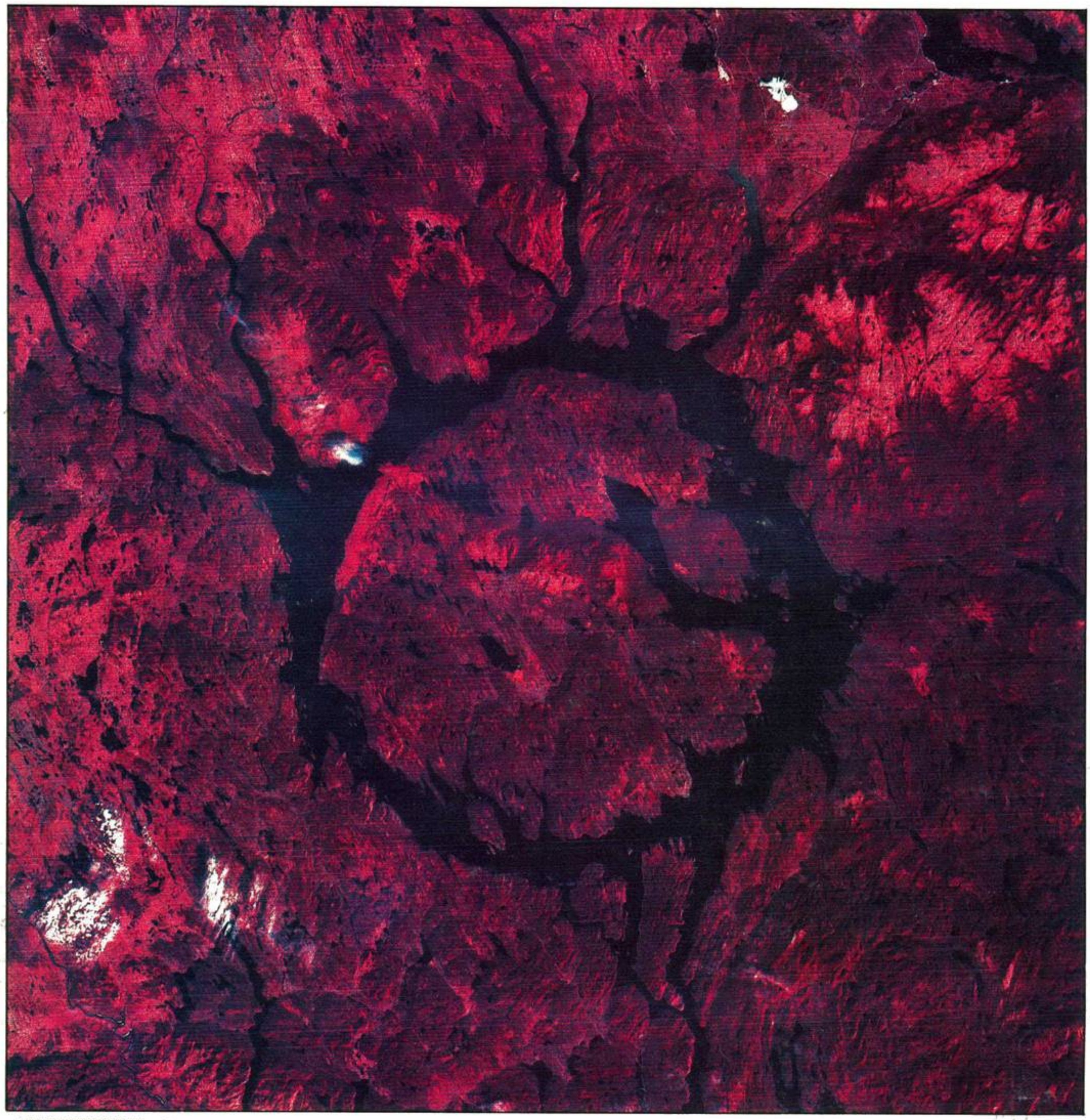
The Fallen Sky

Learn the Spring Constellations

The Soviet Space Shuttle



An Ancient Impact Scar in Quebec

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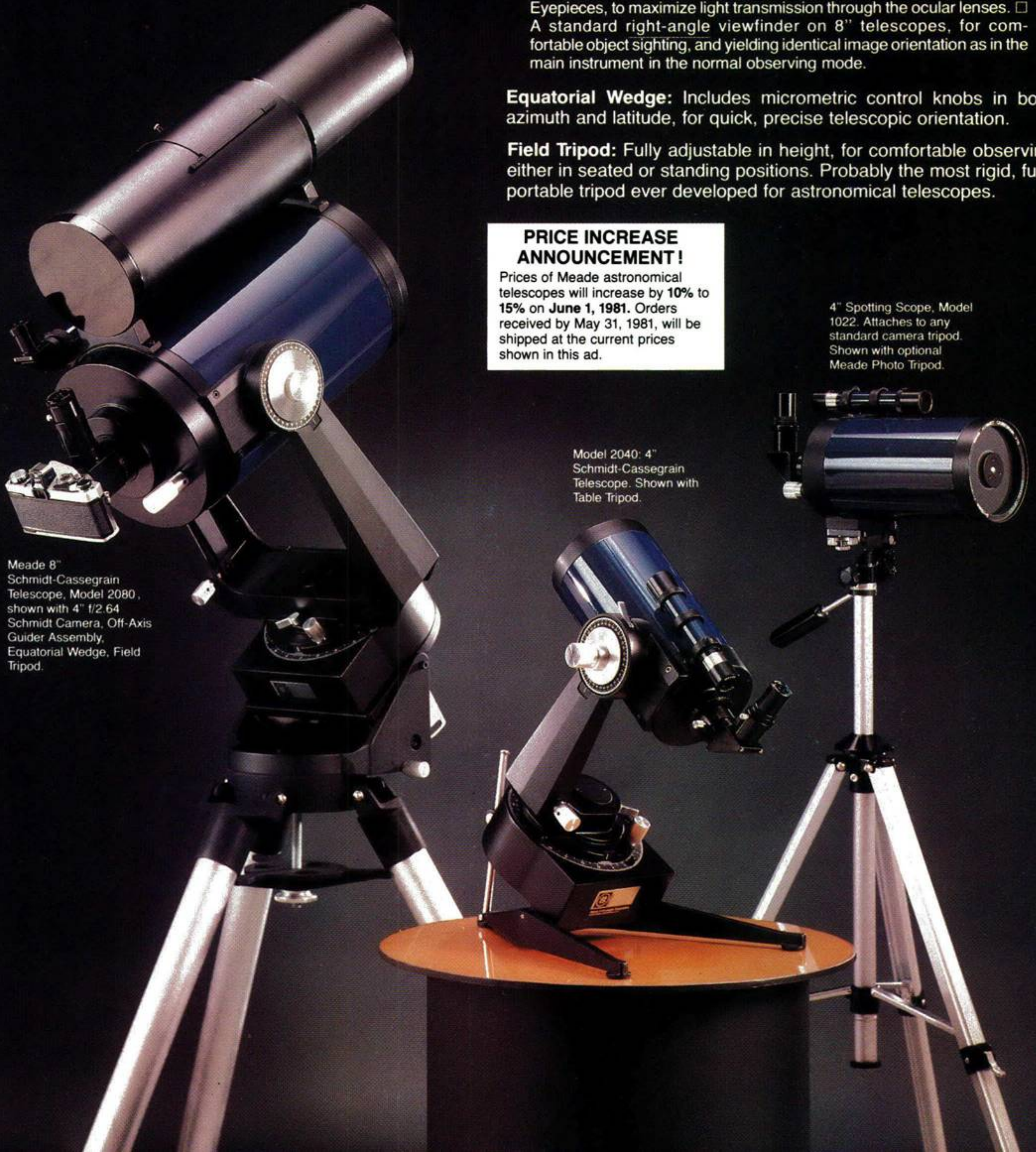

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Model 2040: 4" Schmidt-Cassegrain Telescope. Shown with Table Tripod.

Meade 8" Schmidt-Cassegrain Telescope, Model 2080, shown with 4" f/2.64 Schmidt Camera, Off-Axis Guider Assembly, Equatorial Wedge, Field Tripod.

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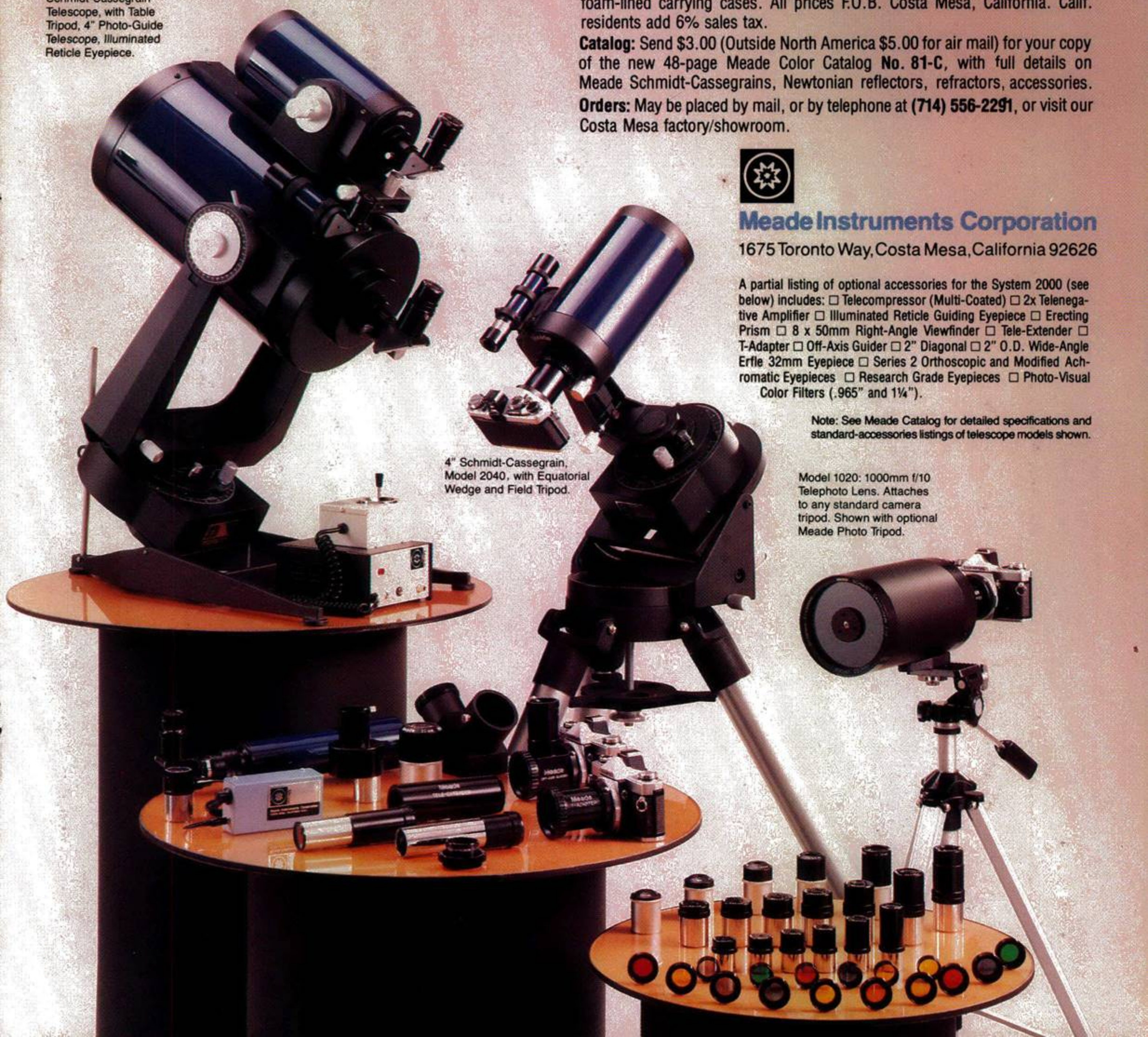
Note: See Meade Catalog for detailed specifications and standard-accessories listings of telescope models shown.



Model 2080: 8" Schmidt-Cassegrain Telescope, with Table Tripod, 4" Photo-Guide Telescope, Illuminated Reticle Eyepiece.

4" Schmidt-Cassegrain, Model 2040, with Equatorial Wedge and Field Tripod.

Model 1020: 1000mm f/10 Telephoto Lens. Attaches to any standard camera tripod. Shown with optional Meade Photo Tripod.

ASTRONOMY

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Cover: About 210 million years ago, a large meteorite slammed into the Earth in what is presently east-central Quebec. Greatly eroded and filled by circular Lake Manicouagan (60 kilometers in diameter), the crater now stands as a monument to "rocks from the sky," the theme of this month's issue. (False-color LANDSAT photo courtesy of NASA.) These pages: A colossal impact scar, the lunar crater Copernicus, as seen by Lunar Orbiter IV. (NASA photo courtesy of Lunar & Planetary Institute.)

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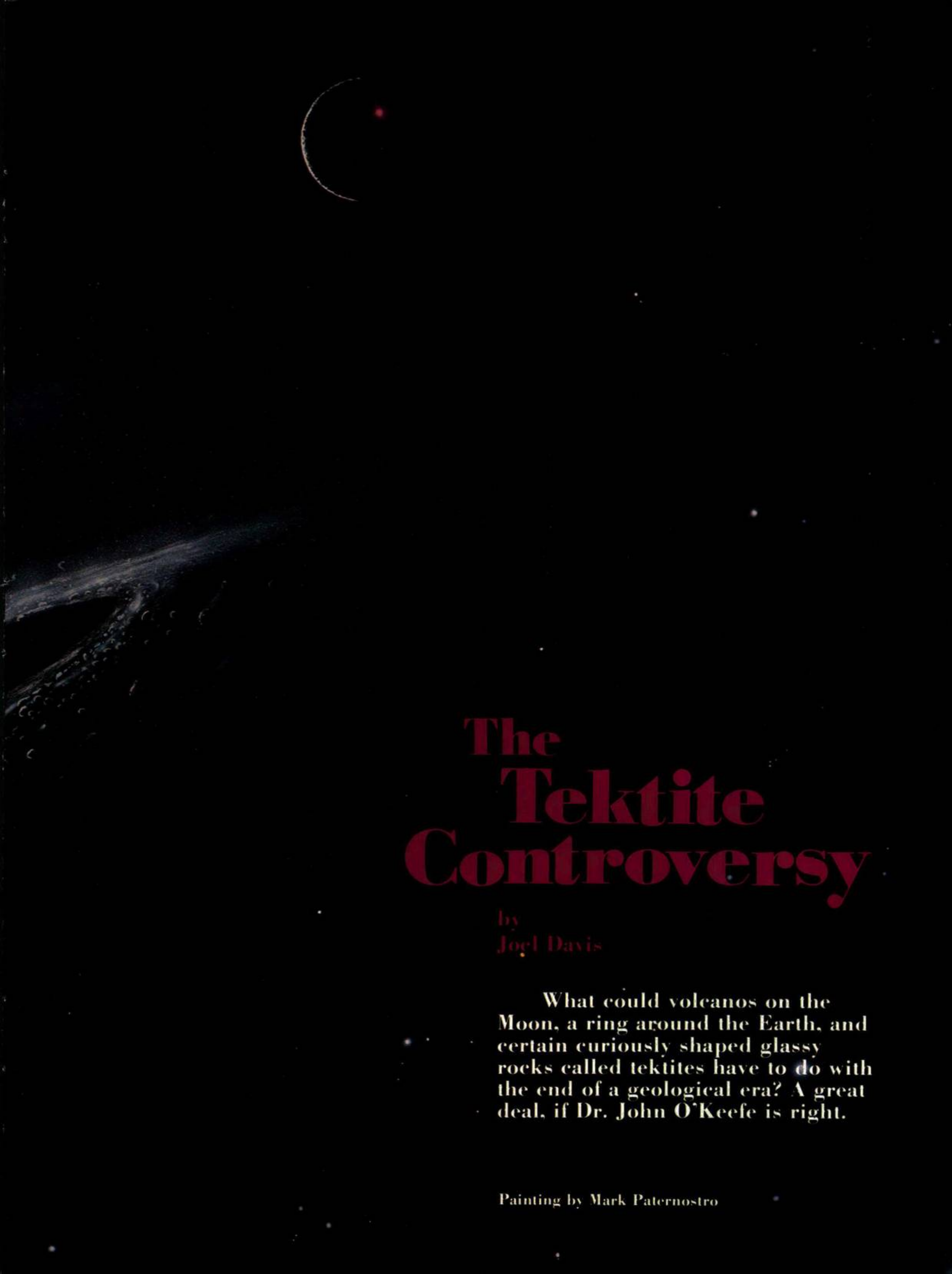
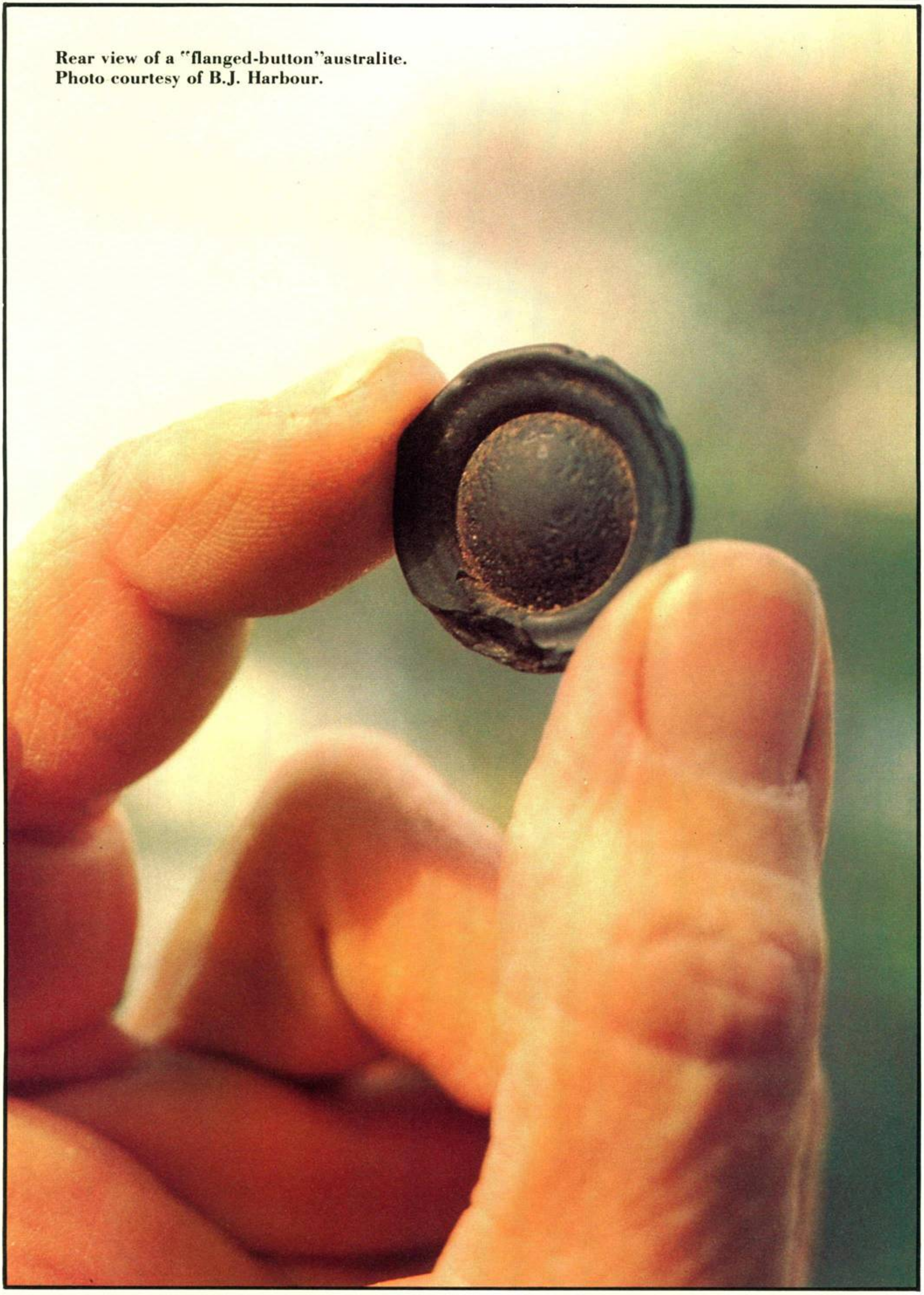


The Tektite Controversy

by
Joel Davis

What could volcanos on the Moon, a ring around the Earth, and certain curiously shaped glassy rocks called tektites have to do with the end of a geological era? A great deal, if Dr. John O'Keefe is right.

Painting by Mark Paternostro



Rear view of a "flanged-button"australite.
Photo courtesy of B.J. Harbour.

> **"...one chemical fact about tektites is utterly baffling: they're extremely dry..."**

More specifically, O'Keefe, a planetary scientist at NASA's Goddard Space Flight Center, believes that a ring of fine particles encircled the Earth 34 million years ago. Its shade temporarily dropped average winter temperatures all over the Earth by about 20° C. The resulting extinction of several species has been named by paleontologists the "terminal Eocene event."

At about this same time, something strewed about a billion tons of glassy rocks across a path stretching nearly halfway around the Earth.

O'Keefe thinks both events were separate but related parts of what he calls a "tektite event." And his theory is the latest episode in a scientific controversy that has simmered for nearly 200 years. It still shows no signs of cooling off.

Tektites: Glassy and Dry

What are tektites made of? Before we can even begin to guess their origins, we must first examine their properties as they are found. If you hold a tektite in your hand, you're immediately struck by its resemblance to a blob of glass. That's not so far off: tektites run from 58 to 85 percent silica (SiO_2), and some specimens of Libyan Desert glass, a type of tektite, are 98 percent silica — almost pure glass. The typical tektite is about 70 percent silica, with the remaining constituents being potassium oxide, titanium dioxide, alumina, ferric and ferrous oxide, magnesium oxide, sodium monoxide, and calcium oxide or quicklime.

The other chemical fact about tektites is utterly baffling: they are extremely dry. There's hardly any water trapped in tektites, a fact which is truly amazing. Most igneous rocks — even though they are created in the hot interior of the Earth — are rather "wet." They contain about 5,000 parts per million (ppm) of water. Sedimentary rocks, formed in water, rate even higher in water content. But a typical tektite has only about 100 ppm of water.

If you took two pieces of rock, both black and glassy, one a tektite and the other a piece of obsidian (a type of volcanic glass), how could you tell which was which? Take a blowtorch and put the flame to each rock. The obsidian — which is a sopping wet sponge compared to the tektite —will bubble and froth as the water trapped inside is forced out. The tektite will merely turn into a molten lump.

Scientists have compared the chemistry of typical tektites and standard samples of granite, basalt, and andesite (a rock chemically between basalt and granite). The result? Tektites turn out depleted in the volatile elements compared to these rocks. They are low in elements with cool melting points, such as tin, lead, copper, and bismuth. Nor do they contain much of the valuable elements like cobalt, gold, iridium, nickel, osmium, or platinum. They also have much less chlorine, zinc, phosphorus, and antimony than do typical granites, basalts, or andesites.

A dumbbell-shaped tektite. (All tektite photos courtesy of Dr. John O'Keefe.)

These last three types of rock are major kinds of igneous rocks, those formed deep in the Earth's interior and erupted out through volcanos. As a rule, tektites are richer in magnesium, iron, cobalt, and nickel than granites — but have a bit less of those elements than basalts. And they have almost the same amounts of these elements as the intermediate andesites.

So tektites present a chemical puzzle. They differ from three major kinds of igneous rock in significant ways, yet are similar to one — andesite — in some respects. (In fact, tektites have more chemical similarity to *sedimentary* rocks than to some igneous rocks, because many sedimentary rocks are also high in silica.) But the dominant fact is the tektite's almost complete absence of water.

Tektite Sites: Scattered from Above

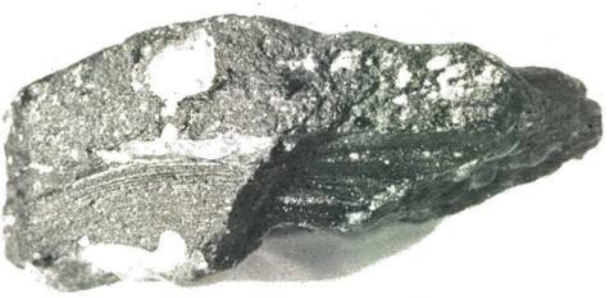
While their chemical composition is unusual, tektites' distribution is even stranger. They lie in four major areas (called "strewn fields") and in three additional isolated sites. Their distribution seems to have nothing to do with either surface or subsurface geology — they are distributed as if they fell from the skies.

The triangular North American strewn field runs from the Caribbean Sea north to Martha's Vineyard and west to Texas. (Some think the field may even extend into the Pacific Ocean, halfway around the world.) Various dating techniques set its age at about 34 million years.

The huge Australasian strewn field stretches from Australia up to the Philippines, Southeast Asia and China, and west nearly to Madagascar. This strewn field is about 750,000 years old.

The Ivory Coast strewn field is an east-west oval with one end on the Ivory Coast of west Africa and the other out in the Atlantic Ocean. Age: about a million years.

Finally, the moldavite strewn field consists of two parallel streaks near the Moldau River in Czechoslovakia. One streak lies 130 kilometers south



A layered muong-nong tektite from Laos.

of Prague and the other, 150 kilometers southeast of the city. The moldavite field is about 15 million years old.

Three other tektite sites exist: one in Egypt (28 million years old), one near the Aouelloul Crater in Mauritania (about 4 million years old), and a newly-discovered site near Irgiz, in Soviet Kazakhstan. The Irgiz tektites seem to be about a million years old.

Tektite Shapes: The 3rd Clue

Tektites are glassy rocks ranging from microscopic to soccer-ball size. Some weigh as much as 12 kilograms, but most are pebble-sized and weigh less than 100 grams. They range in color from black to dark and light brown, to green and yellow.

Tektites come in various shapes including spheroids, teardrops, disks, dumbbells, and lumps. Many found in Australia are semi-spherical with curious flanges. They look like someone took globs of molten glass and hurled them through the air at great speed for long distances. Others are what Virgil Barnes, a tektite expert, has called "splash-forms."

Nearly 20 years ago, Dean Chapman performed a classic experiment that revealed much about tektites. Like many others, he was fascinated by the flanged shapes of the australites. So he and his colleagues took some glass lenses chemically similar to tektite glass, and subjected them to the high-speed searing blast of an arc-jet.

Under the impact of the hypersonic wind, the lenses took on the same flanged shapes as the australites. Another scientist had previously shown how glass spheres could be forced by aerodynamic pressures and high heat to assume lenticular shapes. Chapman concluded that the australite "flanged buttons" must have made a fast, hot trip through the atmosphere at speeds of 6 to 11 kilometers per second. The buttons began as roughly spherical objects that ablated into lenses and flanged shapes. The splash-form tektites were originally of irregular shape, and tumbled during flight. But where did they come from? And what force propelled them?

"...terrestrial volcanos can do many things, but they can't make a tektite..."

Sherlock Holmes, Where Are You?

We now have an impressive number of clues about tektites. We know they are glassy (implying rapid cooling) and dry (as if they had baked in a vacuum). Judging by their distributions, they were strewn onto the landscape from above and they appear to have been heated as if by passage through the atmosphere. What can we make of these clues?

We're pretty sure tektites are not some special form of meteorite, though that might seem the simplest, most convenient explanation. The flaw is the age — not of the strewn fields but of the tektites themselves. Tektites never spent much time in space. Meteorites typically spend millions and even billions of years in space before they are finally caught by Earth's gravity and plunge to the ground. During their drift in space, they are continually struck by cosmic rays.

When cosmic rays slash through a piece of

Tektites: Cro-Magnon to Today

The oldest association between human activity and tektites occurs at Willendorf, Austria, where archaeologists found tektite splinters worked into knives in a site also containing thousands of flint tools and the famous *Venus of Willendorf* statuette. That carving, done by Cro-Magnon people, has been dated to about 29,000 BC.

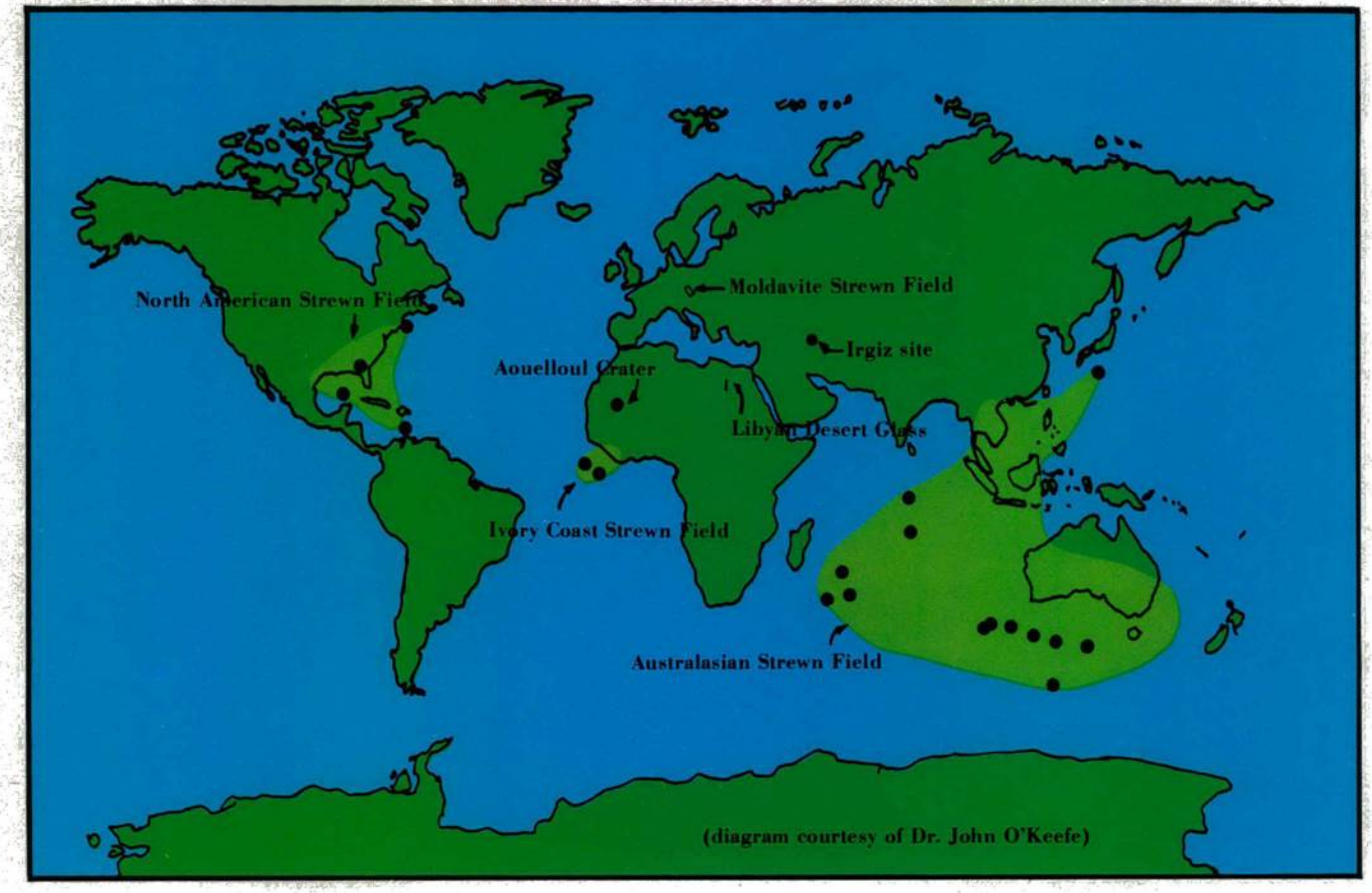
Pre-neolithic peoples in the Philippine Islands 6,000 to 8,000 years ago also turned pieces of tektites into tools. French explorers in Cambodia found a piece of tektite glass buried under a stone idol in a treasure box that had been rifled by looters. The thieves had stolen the treasure and left the tektite.

About a thousand years ago (around when the Cambodian tektite was being hidden), the Chinese writer Liu Sun wrote that people living on the Leichow peninsula would go about the fields after thunderstorms and collect curious black rocks — tektites, no doubt.

The first scientific paper on tektites was written in 1788 by Josef Meyer, and the controversy over their origin dates from then. Charles Darwin thought them similar to volcanic bombs. Others have suspected tektites to be manmade; in 1792, J.T. Kindaker speculated that they were created by prehistoric glass makers. And some have thought tektites to be a type of fulgurite, a mineral formed when lightning strikes sand.

Throughout the years, scientists have disputed the origin of tektites — terrestrial volcanos, lunar volcanos, comets, meteorites, meteor impacts on the Moon or Earth, and the secret laboratories of hoaxers — and still the controversy continues.

World Tektite Sites



(diagram courtesy of Dr. John O'Keefe)

matter, they leave microscopic tracks. Astronomers and geologists can tell approximately how long a meteorite has been floating in space by the number of cosmic ray tracks etched into it. If the ray tracks in tektites equal those of meteorites, then tektites are likely some kind of meteorite.

They don't. In fact, no cosmic ray tracks are found in tektites at all. This means their "space exposure time" can have lasted only 900 to 6,000 years — at most.

Could tektites then be the shattered remains of a comet nucleus or asteroid that hit the Earth? The 1908 Tunguska impact in Siberia was probably that of a comet. And there are plenty of super-sized crater remnants (astroblemes) to show where sizable flying mountains have impacted Earth in the past. Yet no tektites have ever been found near astroblemes or the Tunguska site. Nor are there any astroblemes near enough to the strewn fields for a convincing connection. Finally, the total lack of cosmic ray tracks argues against a comet or asteroid theory of origin.

Could tektites then have been blasted off another planet, to fly through space and land here? It's very, very unlikely, because, first of all, the stream of matter would spread so far and wide during the multimillion kilometer journey that tektites would be evenly scattered over at least one hemisphere of Earth. They're not. Second, because space is big and the Earth small, a long time would elapse before they hit us, and the cosmic ray track record rules this out.

Which leaves the Moon — or somewhere on Earth itself. And the propulsive force can be only meteorite impact or volcanic eruptions, since no other mechanism has enough energy.

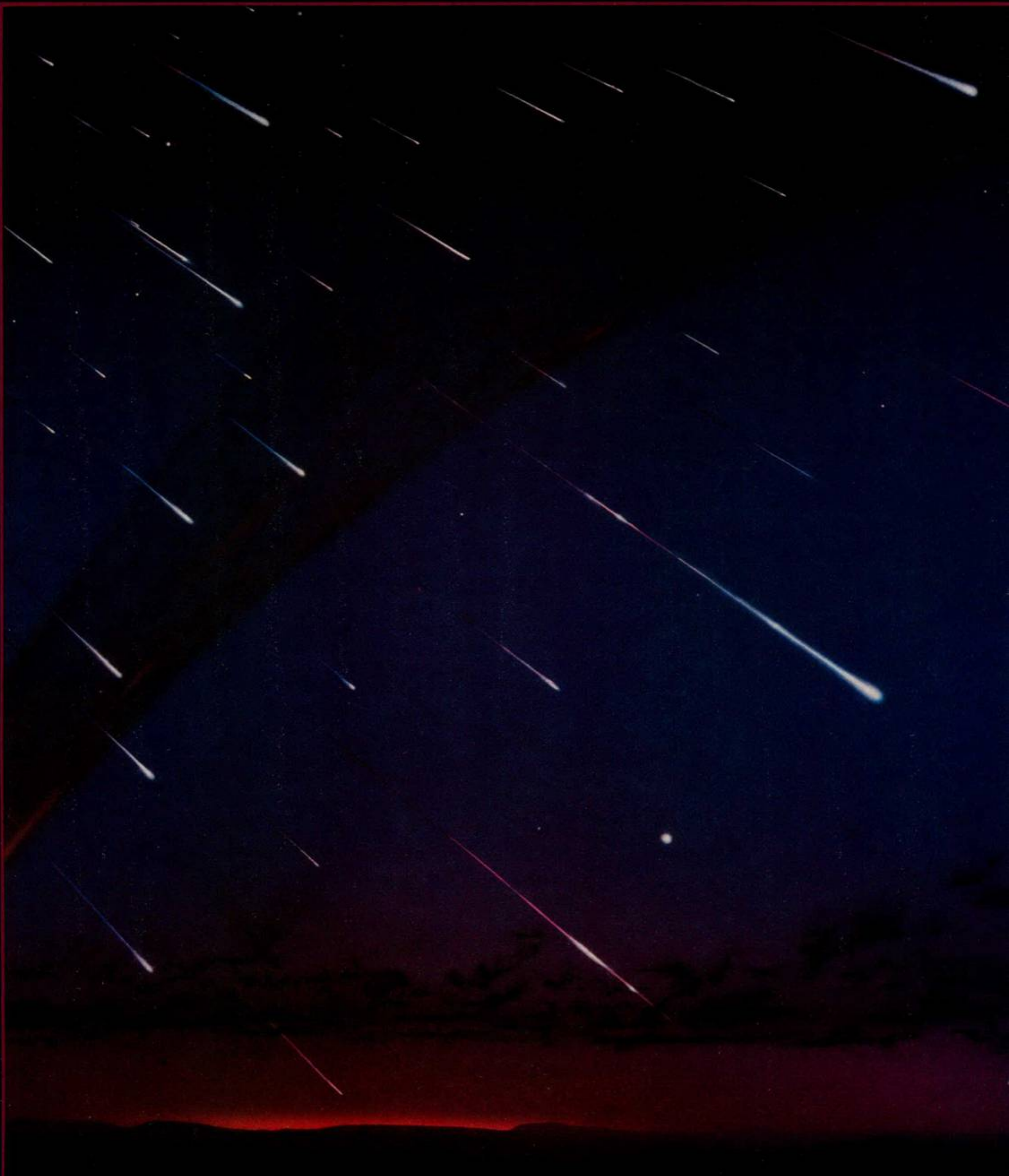
The Double Planet

If tektites must have come from one of the two partners of our "double planet," the question is which? The idea that tektites are actually terrestrial has long been strongly supported. Proponents of this view have included Charles Darwin and the late Nobel prize-winning chemist Harold Urey, and today include the eminent tektite scientist Virgil Barnes.

As noted earlier, tektites have some chemical similarity to andesitic volcanic rocks, and have often been mistaken for obsidian and other kinds of volcanic glass. What if that's not a mistake? Perhaps tektites were thrown high above the atmosphere by some violent volcanic explosion, to follow a long ballistic arc and re-enter the atmosphere to land in "strewn fields."

Unfortunately, origin in terrestrial volcanic eruptions is hard to explain. Violent volcanic explosions (like that of Mount St. Helens last year) happen when water dissolved in magma suddenly boils out of solution as the pressure on the molten rock abruptly drops. The water flashes to superheated steam and everything blows sky-high.

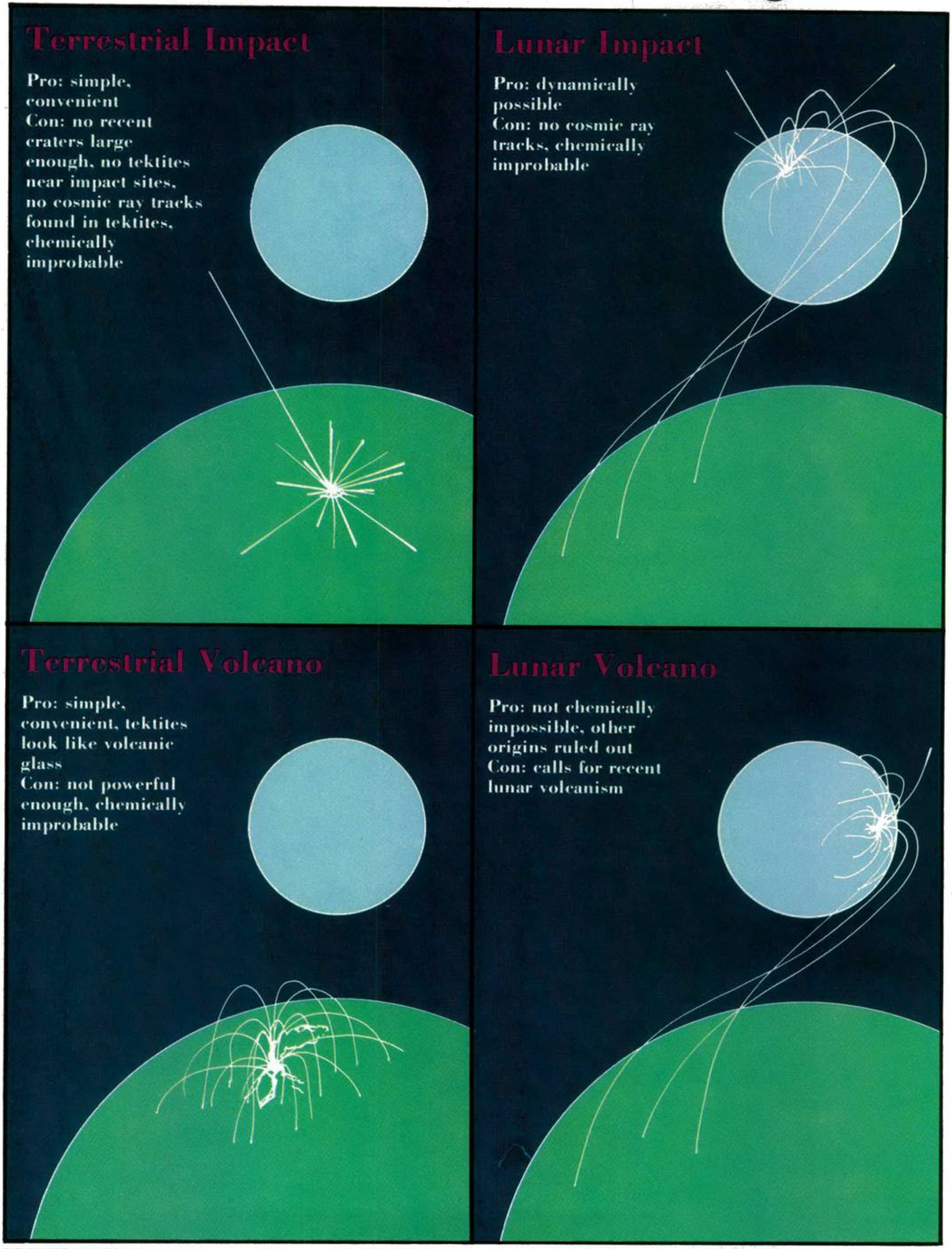
But not high enough. The greatest velocity a rock blown out of a terrestrial volcano can reach is around 700 meters per second. That's not fast enough to get a



Thousands of tektites fall onto a nameless landscape under the glowing arc of Earth's temporary ring some 34 million years ago.

Painting by Mark Paternostro

Arguments on Tektite Origins



Terrestrial Impact

Pro: simple, convenient
Con: no recent craters large enough, no tektites near impact sites, no cosmic ray tracks found in tektites, chemically improbable

Lunar Impact

Pro: dynamically possible
Con: no cosmic ray tracks, chemically improbable

Terrestrial Volcano

Pro: simple, convenient, tektites look like volcanic glass
Con: not powerful enough, chemically improbable

Lunar Volcano

Pro: not chemically impossible, other origins ruled out
Con: calls for recent lunar volcanism

"...might not hot hydrogen gas explode out of a lunar volcano, blowing off tektite material..."

pebble above the atmosphere. For example, to account for the observed spread of tektites in the Australasian field, a hypothetical volcano at its center would have to spew matter out at about 6,000 meters per second.

Terrestrial volcanoes can do many things — but they can't make tektites.

What about impacts, then? Could a large meteorite or small asteroid strike the Earth and blast terrestrial rock and dust high enough above the atmosphere to carry it thousands of miles? And, having done this, could it simultaneously force nearly all the water from the rocks, leaving hardly any bubbles inside?

The Australasian and North American strewn fields are huge. The North American field probably contains at least a billion tons of tektites; the Australasian, about 100 million tons. To create the mass of the North American field, says John O'Keefe, would mean blasting out a crater some 100 kilometers in diameter.

An astrobleme of such size has never been found anywhere within the extent of the North American field. The same holds for the Australasian strewn field — no crater or astrobleme sufficiently large. What's more, although the tektites in the Australasian field can be grouped into streaks, the streaks don't radiate from a common center. In fact, many are parallel.

Bediasite tektites from Grimes County, Texas.

Several tektite fields or sites have craters associated with them, and a number of tektite experts feel this is more than coincidental. The Ries crater in southern Germany lies not far from the moldavite strewn field. There's an impact crater near the Libyan Desert glass site. The tektites in Mauritania are named after the Aouelloul Crater. And some geologists suggest the Ivory Coast strewn field has connections with the Bosumtwi crater in Ghana.

A Tektite is a Tektite ...

Tektites are often named for the area in which they are found. This explains why the tektites found near Irgiz are irgizites and those found near the River Moldau in Czechoslovakia are called moldavites; Australian tektites are australites. There are also indochinites (found in Indochina) and billitonites (from the Indonesian island of Billiton).

But not all tektites are named in such a fashion. The tektites found near the Egyptian-Libyan border are called Libyan Desert glass, and on the island of Tasmania where Charles Darwin first found tektites, they are called Darwin glass. Certain kinds of tektites found in southeast China are called *lei-gong-mo*, meaning "inkstone of the thundergod." Lastly, the tiny tektites found in deep-sea ocean floor cores are simply called microtektites.

The modern term tektite (a coinage dating back to 1900) comes from the Greek *tektos*, meaning molten.

But the problems are: 1) The two streaks of the moldavite strewn field lie perpendicular to the Ries crater, instead of radiating from it. (No tektites have ever been found near the Ries crater itself.) 2) The center of the Ivory Coast strewn field is 900 kilometers from the Bosumtwi crater and the field simply doesn't radiate from it. 3) There's no chemical similarity between moldavites, Ivory Coast tektites, microtektites, and the rocks around the supposed "craters of origin." 4) There seems to be no way a meteorite or asteroid impact could instantly dry out terrestrial rocks, melt them through and through, and alter their chemical composition — all at once.

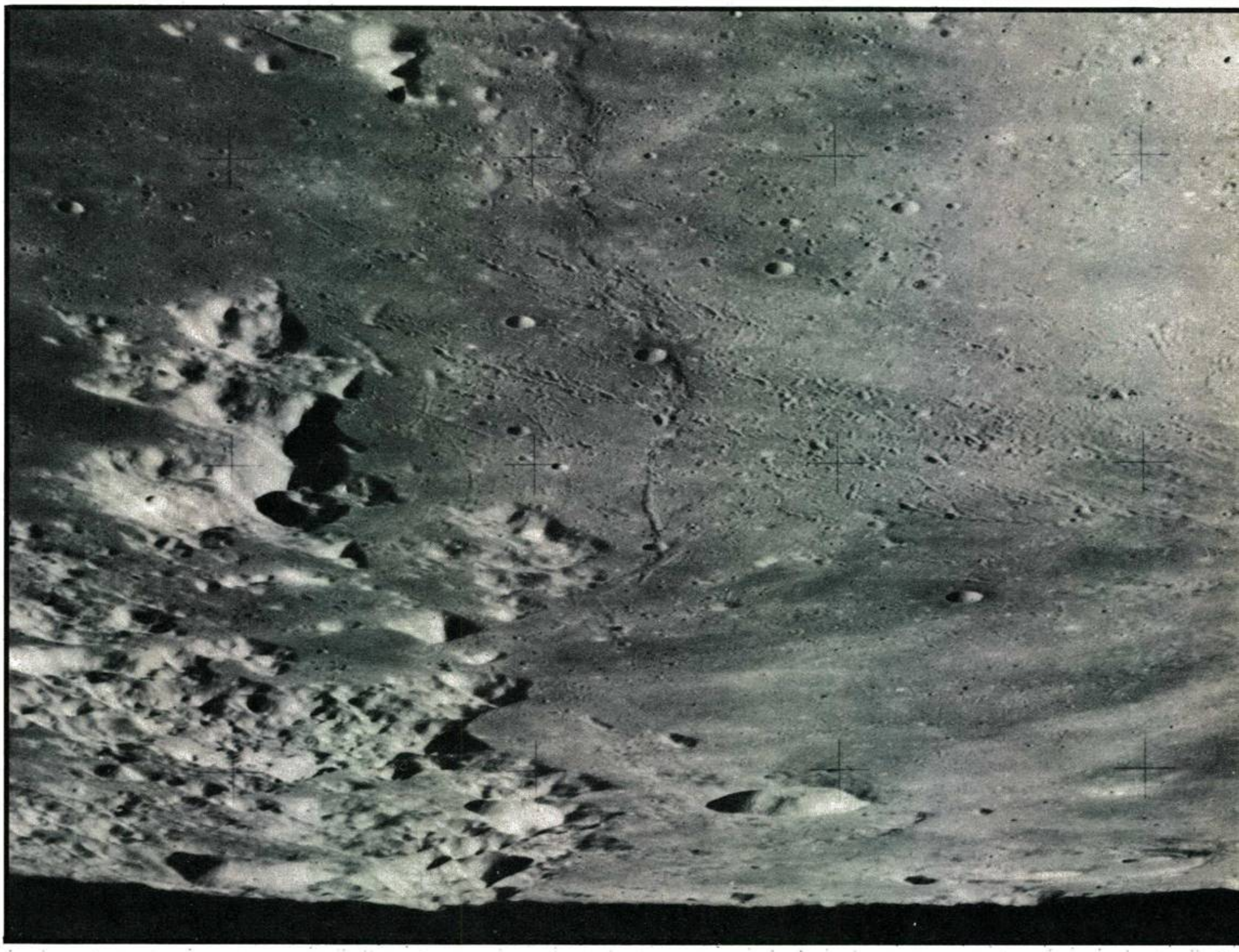
"...Whatever Remains..."

So, like it or not (and some geologists don't), this leaves only the Moon as a source for tektites. The question now becomes, was it an impact or a volcanic eruption?

Meteorites and asteroids have peppered the Moon for eons — though the biggest impacts came during the first billion or so years of its existence. A simple look through a telescope shows scars from gargantuan impacts. Could such an impact release enough energy to spray lunar matter out into space?

In 1971, Dean Chapman suggested this is what created the Australasian field of tektites. He theorized this strewn field came from material blown off the Moon by the same impact that made the bright rayed crater Tycho. He even pinpointed the ray he thought the tektites came from.

The Australasian strewn field is only three-quarters of a million years old, and if Chapman is right, it means Tycho was created a geological eyeblink ago. There's evidence that several English monks witnessed a lunar meteor impact only 800 years ago, forming the farside crater Giordano Bruno. However, three serious objections work against a



lunar impact origin for tektites: chemistry, cosmic rays, and what O'Keefe has called the "Anders limit."

First, there are large chemical differences between tektites and lunar surface rock — as the Apollo samples have shown. Most lunar surface material is either a type of basalt (rich in iron and feldspar) or a rock called KREEP, which stands for a mixture of potassium (K), Rare Earth Elements, and Phosphorus.

Tektites just don't resemble any of these rocks. A few tiny particles which are either pure silica glass or remarkably similar in other ways to tektites have been found in lunar samples. But these are very few and compositionally insignificant.

Then again, there's the lack of cosmic ray tracks in tektites. If tektite-matter were part of the lunar regolith, it would have been exposed for a long time to cosmic ray bombardment — and we'd see the traces.

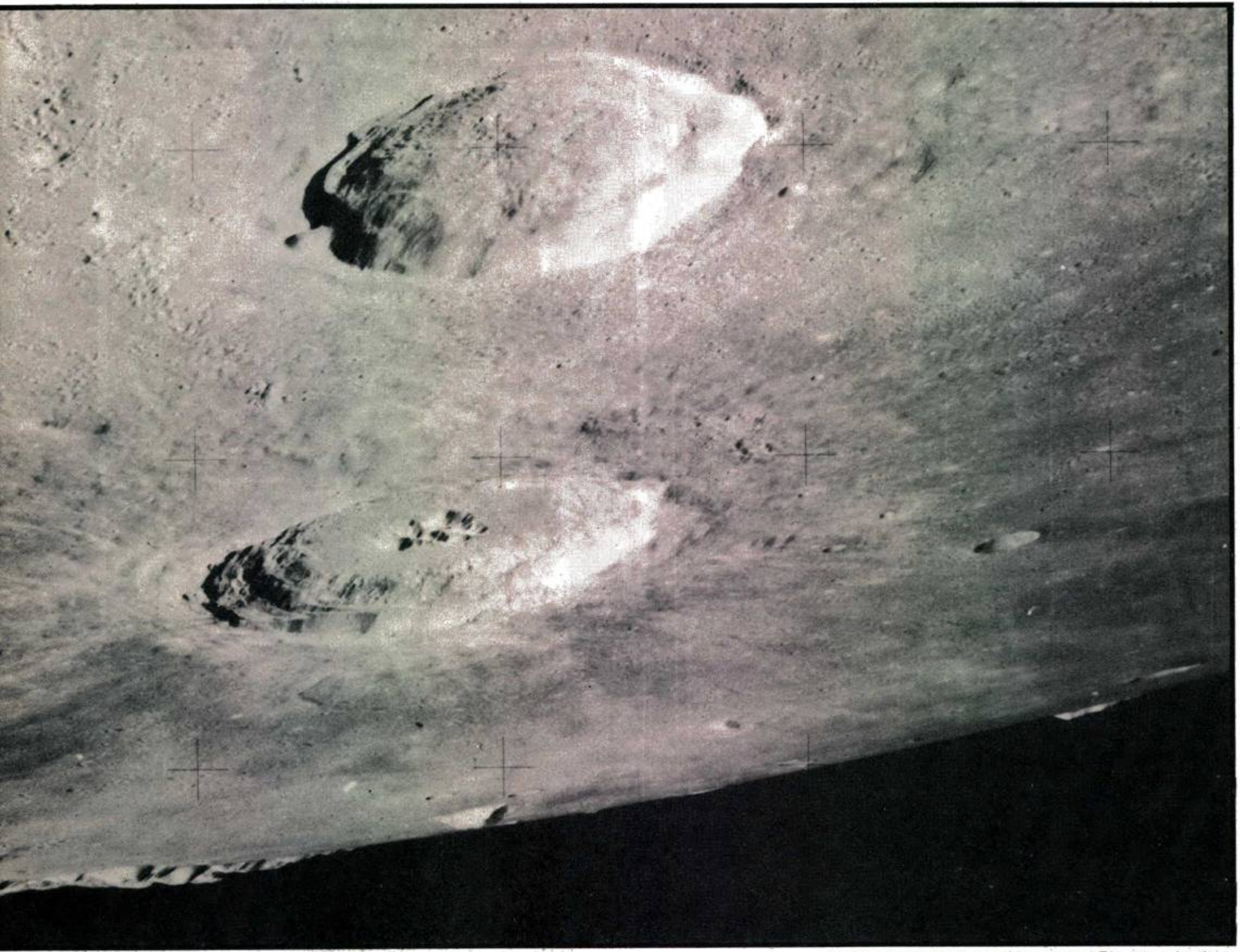
Finally, there's the "Anders limit." Edward Anders of the University of Chicago pointed out that if meteors hitting the Moon could splash lunar rock all the way to Earth, we should have some meteorites "on the shelf" that are similar in composition to lunar surface rocks.

But we haven't any, and Anders suggests this means that meteor impacts on the Moon don't expel significant amounts of matter at the Moon's 2.5 kilometer per second escape velocity. So there's no way a meteorite hitting the Moon could create tektites found on Earth.

...The Answer?

This leaves a lunar volcanic origin for tektites, and that's hard to believe, too. It implies that lunar volcanos are powered by a mechanism different from that of terrestrial volcanos, and that the material deep within the Moon is different from that at the surface but similar to some terrestrial rocks. Lastly, it implies that the Moon has been geologically active in the recent past.

Lunar volcanos do exist. Some, for example, appear in photos of the crater Alphonsus where several so-called "transient events" have been spotted by some astronomers — red glowing gases were observed there in 1958 and 1959. Similar transient events occurred near Aristarchus in 1963. The seismographs left by Apollo crews register occasional small moonquakes, indicating some



NASA photo courtesy of Lunar and Planetary Institute

geologic life is left in the Moon. But active volcanos?

If they do exist, John O'Keefe thinks they'd be powered by hydrogen gas, not steam as are terrestrial volcanos. In his theory, any water escaping from lunar rocks deep within the Moon would be broken down into hydrogen and oxygen by the heat of lunar magma. We know that lunar rocks are extremely "reducing," that is, they soak up oxygen as a sponge soaks up water. This leaves hot hydrogen gas to explode out of a lunar volcano, blowing material straight up into the heavens.

He figures the speeds to be considerably greater than the 2.5 kilometers per second necessary to eject material from the Moon's gravitational pull. In fact, calculations show that particles launched by a hydrogen-powered volcano could easily reach velocities of up to six kilometers per second.

Some of the material would go into trajectories taking it out of the Earth-Moon system altogether. Other material would fall into orbits, eventually becoming a flat ring in Earth's equatorial plane. There it would screen sunlight and wipe out a few species before it dissipated in a few million years under the force of gravitational perturbations and the pressure of sunlight. And, some material would fall to the ground in relatively tight patterns — to be found later as tektites.

Lunar rock from deep within the Moon's interior would have no cosmic ray tracks in it. Its travel time would be far too short for cosmic rays to etch it before it reached Earth. Chemical composition? There's little doubt that most lunar material at shallow depths is pretty much like the surface. The flat, dark maria were formed by molten basalt floods spilling out after asteroid impacts. But it's also possible that small pools of granitic or andesitic — tektitic — matter may exist down deep under the lunar regolith.

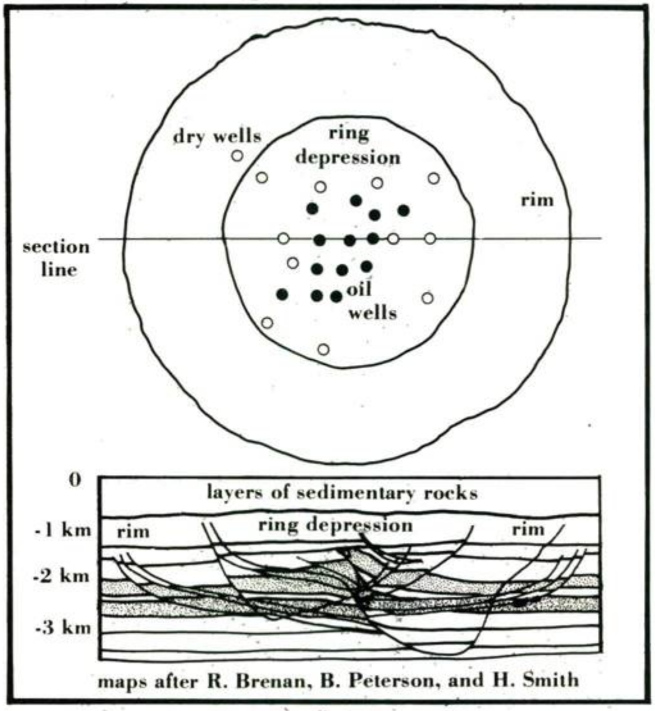
Admittedly, this theory is very speculative, for it makes many assumptions. But what possibilities remain? "When you have eliminated the impossible, whatever is left, however improbable...," said Sherlock Holmes. And although he didn't have tektites in mind, this may be a celestial detective story nearing its solution.

Joel Davis is a science writer living in Olympia, Washington. His last article for ASTRONOMY was "The Sun-Grazers" in the August 1979 issue.

Mining a Meteor Crater

by
Andrew Maslowski

Red Wing Creek Structure



maps after R. Brenan, B. Peterson, and H. Smith

Mention "mining the asteroids" and most people will think of 1950s science fiction — grizzled space prospectors piloting beat-up rust buckets — and smile. And if we ever do mine asteroids, it certainly won't be the Old West transported two astronomical units out, but a high-tech government project. Still, the idea itself is far from crazy, because we've been mining asteroids' cousins — meteorites — for some time already, right here on Earth.

At least two significant economic deposits in North America are now generally thought to be extraterrestrial in origin: the nickel mines at Sudbury, Ontario and the Red Wing Creek oil field near Williston, North Dakota. Although it's unlikely the two meteorites that created these structures are being directly exploited, their impacts caused great local distortions in the Earth's crust that started the accumulation of valuable mineral resources.

Sudbury is an isolated city in Ontario, 325 kilometers northwest of Toronto and 65 kilometers north of Georgian Bay, a deep inbite on Lake Huron's eastern shore. Its geography is unique for many reasons.

The Sudbury crater, known topographically as the Sudbury Basin, is the largest of the many craters on the Canadian shield visible from space. Substantially eroded and deformed, the crater (or what now remains of it) is 24 kilometers wide and 56 kilometers long. Its barren, lunar-like landscape prompted NASA to select it as a training ground for Moon-bound Apollo astronauts in the late 1960s. Besides rich supplies of copper, iron, and platinum-group metals, the Sudbury Basin also contains close to half of the world's known reserves of nickel, a metal very important in industry — not to mention five-cent pieces!

Approximately 1.7 billion years ago, a brilliant fireball perhaps four kilometers in diameter fell upon some nameless terrain. The impact of this rock created a bowl over 2,500 meters deep and threw up a rim over 1,000 meters high. Like the famous Meteor Crater in Arizona, this impact generated no major central peak.

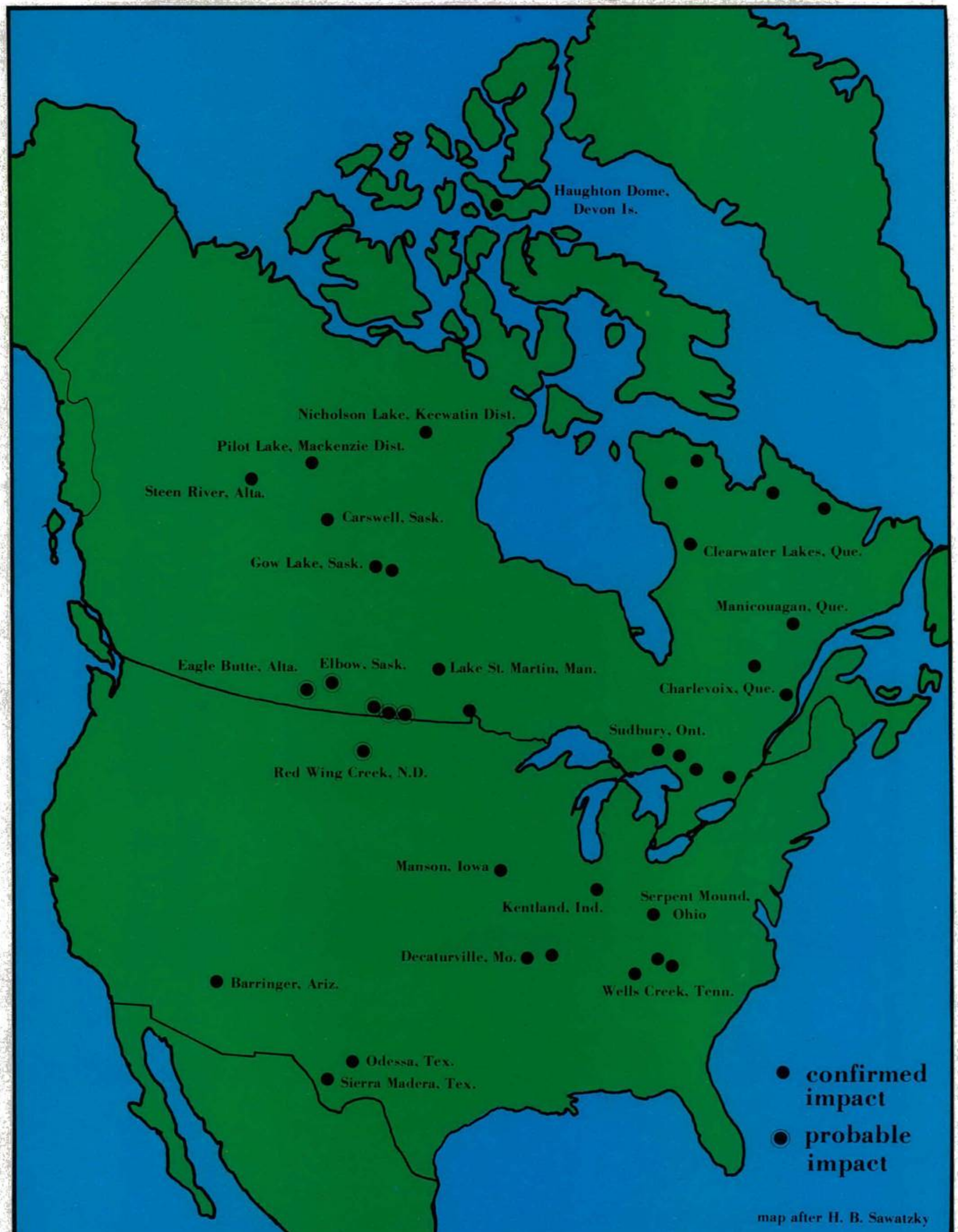
The shock of the meteor strike, combined with the associated heat, caused nickel, copper sulfides, and other metallic compounds already present deep in the rock strata to rise in a semi-liquid state through cracks in the fractured rock. The nickel, iron, copper, platinum, and other minerals mined today at Sudbury do not have an extraterrestrial origin. Rather, these metals became "minable" because of the impact and explosion.

There's no question that the Sudbury Basin was a meteor strike: rock-forms characteristic of high temperature and pressure, and shock features prove unequivocally that a meteor hit there.

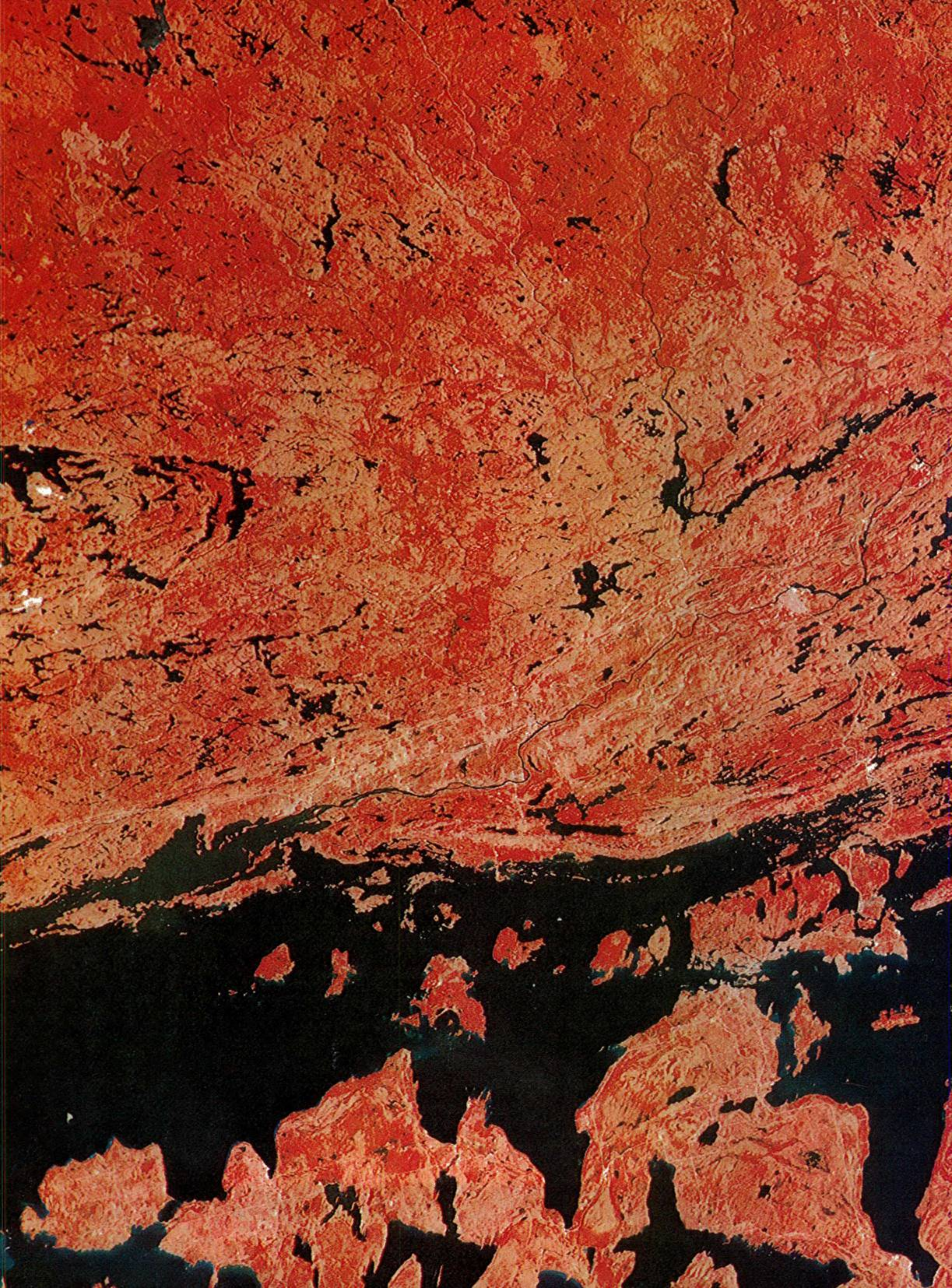
The Red Wing Creek structure, however, has no such clear-cut origin — but it's easy to understand why: located about 65 kilometers south of Williston, North Dakota (in Theodore Roosevelt National Memorial Park), it can't be seen from the surface, air, or space. The structure lies buried 1500 to 4000 meters down, and would still be unknown if it weren't for the rock samples gethered from exploratory oil wells drilled there. Since its discovery in 1972, the Red Wing Creek field has produced over five million barrels of crude oil. It may well be the only oil field in the world associated with a meteor impact.

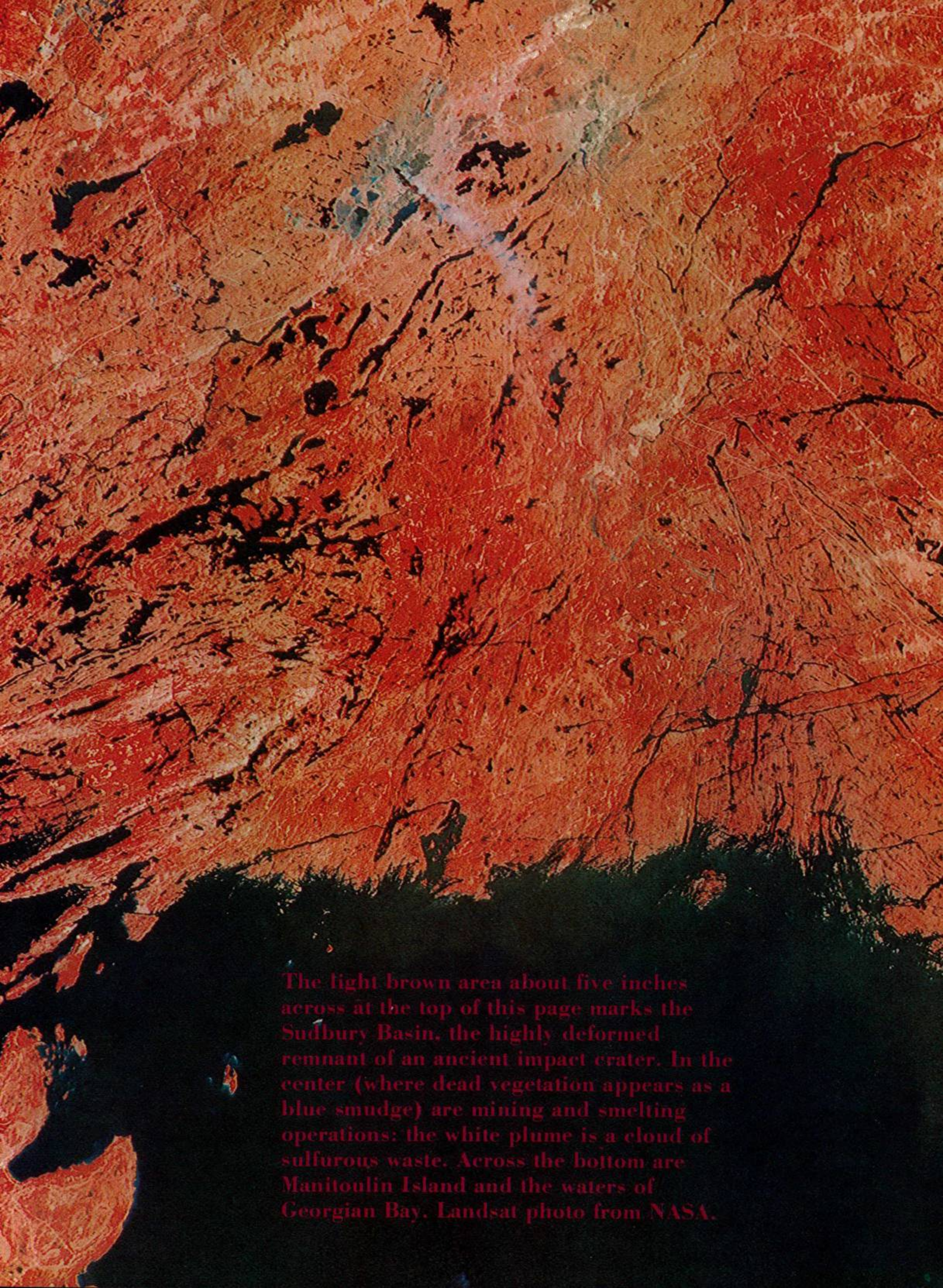
About 140 to 230 million years ago, in Triassic or Jurassic time, while dinosaurs were grazing around most of the Rocky Mountain region, a meteorite probably crashed here, leaving a crater about five kilometers in diameter. This crater must have had a central peak, for the uplift and subsequent fracturing

North American Impact Sites


Haughton Dome, Devon Is.
Nicholson Lake, Keewatin Dist.
Pilot Lake, Mackenzie Dist.
Steen River, Alta.
Carswell, Sask.
Gow Lake, Sask.
Clearwater Lakes, Que.
Manicouagan, Que.
Eagle Butte, Alta.
Elbow, Sask.
Lake St. Martin, Man.
Charlevoix, Que.
Sudbury, Ont.
Red Wing Creek, N.D.
Manson, Iowa
Kentland, Ind.
Serpent Mound, Ohio
Decaturville, Mo.
Barringer, Ariz.
Wells Creek, Tenn.
Odessa, Tex.
Sierra Madera, Tex.
● confirmed impact
◉ probable impact

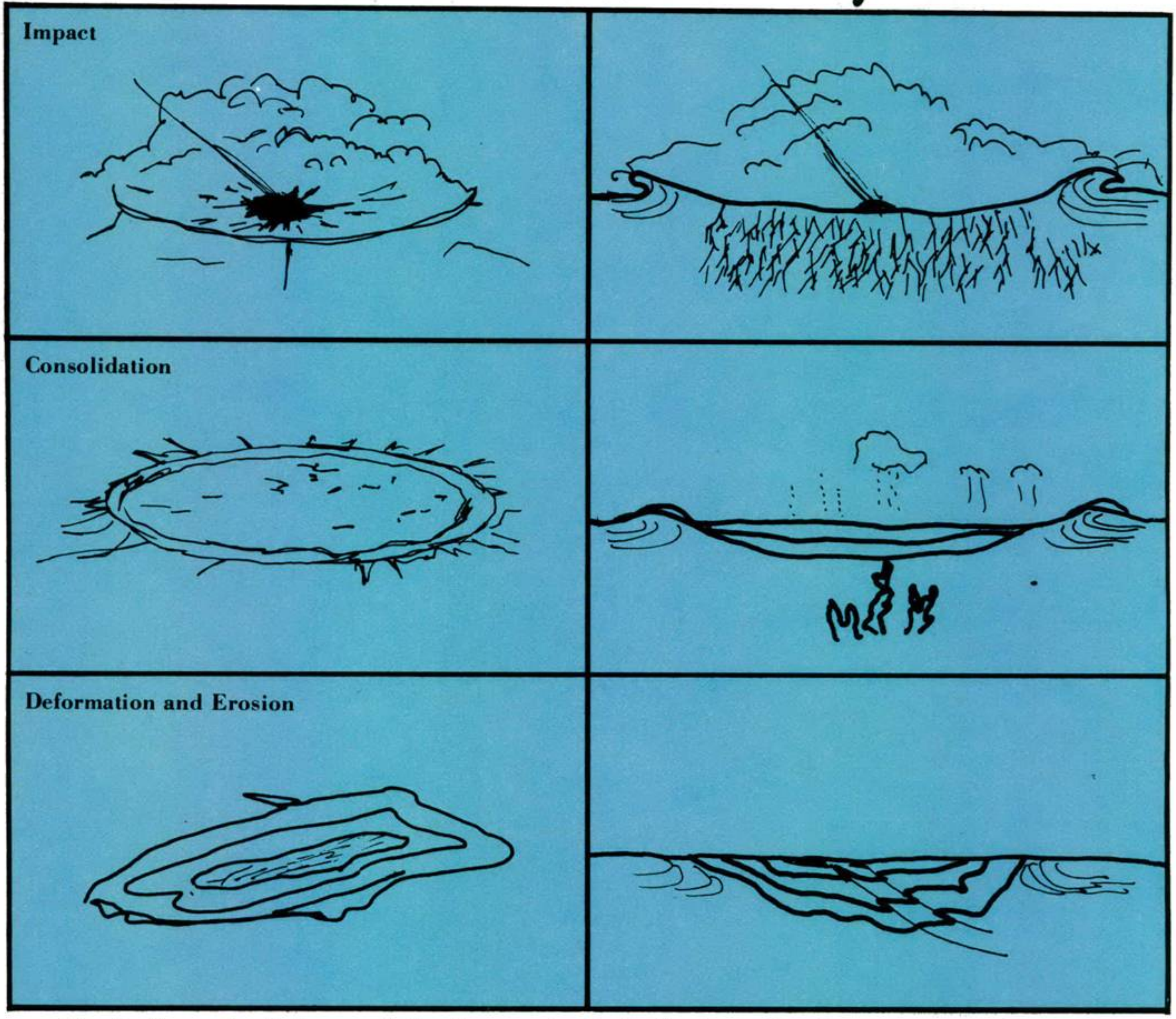
map after H. B. Sawatzky





The light brown area about five inches across at the top of this page marks the Sudbury Basin, the highly deformed remnant of an ancient impact crater. In the center (where dead vegetation appears as a blue smudge) are mining and smelting operations: the white plume is a cloud of sulfurous waste. Across the bottom are Manitoulin Island and the waters of Georgian Bay. Landsat photo from NASA.

Evolution of the Sudbury Basin



The Sudbury shock fractured the "country rocks," allowing minerals to migrate and consolidate into deposits. The basin's shape today reflects millions of years of erosion and deformation.

at the center caused oil to accumulate.

The field's circular shape and central uplift are two major pieces of evidence for the meteorite theory. Geologists think the Williston Basin, a large structure that spreads across North Dakota, Montana, South Dakota, Saskatchewan, and Manitoba, is "quiet," having few violent, high-energy Earth movements. Furthermore, shatter cones (shocked rock features) much like those found at Sudbury — and characteristic of impact sites — have been found in rock cores taken from nearby wells. In short, the meteorite explanation is the most likely.

Nevertheless, some geologists believe this structure represents the union of several complicated faults, and the circular shape, central uplift, and shatter cones came about through faulting and Earth-movements. But however the dispute is settled, it's clear that the Sudbury crater and the Red Wing Creek structure are both scientifically and financially important.

Asteroid mining may yet have its day — the potential scientific and economic rewards are immense — but who knows when it will happen? On the other hand, searching out economically important meteorite deposits throughout the world usefully combines advances in solar system geology with marketable discoveries — and we're doing it today.

Andrew Maslowski is a petroleum geologist and free-lance science writer.

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ASTRONOMY FORUM

President Reagan: Go For It!

Despite its absence from the rhetoric of the recent presidential campaign, the American commitment to space exploration and development is no small issue. As a concerned scientist, I've wondered: Why no discussion? Apparently the last time most Americans noticed the space program, it seemed to be just another drain on our government as we space-raced our way to the Moon. After praising the profound historic achievement of Apollo in 1969, the American public has failed to take a deeper look at the space program, its true costs, benefits, and rationale.

We now have an 11-year perspective on Apollo and the space program and are realizing the benefits, not just footing the bills. Space interest groups are proliferating — and their memberships expanding at a rate equaling that of the environmental movement at the time of its beginnings in the mid-60s.

What of the billions of dollars in costs? No, not the hundreds of billions that one acquaintance of mine recently guessed — just billions. In fact Americans annually spend more on, for example, toys, cosmetics, cigarettes, or pizza. Another perspective on the costs: In 1978, the U.S. Department of Health, Education and Welfare (HEW) revealed a loss due to welfare fraud and inefficiency equal in amount to over a time and a half the government's investment in NASA. And for those who may yet view the space program as only a drain from the government's support for its social welfare programs, I want to point out that what remains of HEW today (Health and Human Services; Education has been made into a separate department) spends the entire annual NASA budget in about 10 days! And the Department of Defense expends the annual NASA budget in about two weeks.

Only a bit less than one cent out of each tax dollar you pay goes to NASA. That figure may surprise you, but if there is any competition for funding between NASA and these other programs, it is clear that NASA comes in a distant third.

The benefits of a progressive space program are highly commensurate with some major goals, as I see them, of the Reagan administration and Republican Party, and because of the party's success at the polls, many Americans as well. Here are the goals and some ideas on the positive role the space program can play in realizing each:

NASA

- To Stabilize Our Economy. The increased understanding of our universe, because of America's exploration of space, has been indisputably enormous. The content of the course on the solar system which I took as an undergraduate in the late sixties was dry and empty compared to the riches I present to today's undergraduates. Those photographs sent back by the modern explorers called Viking, Mariner, Voyager — of exotic places like Chryse on Mars, Io, Titan, the rings of Saturn — are priceless. And what of those awareness-expanding photos (taken by the Apollo astronauts) of a distant, delicate and precious Spaceship Earth?

There are also generally unrecognized economic and material benefits from space. These benefits, both direct and indirect, greatly outweigh initial investment. Here are just a few examples:

1) The communications satellite business, already a billion dollar a year industry, is expected to double within just a few years. It was NASA which provided the necessary lead development, and the government, the inital investment in COMSAT.

2) The demands of space exploration and development have revolutionized the computer industry. One should pause to consider how many jobs have been created, and the number of ways computers are making life easier, cheaper, more productive (anti-inflationary), safer, and more enjoyable.

3) The National Oceanic and Atmospheric Administration (NOAA) evaluated in 1978 their satellite programs and came up with actual dollar figures which showed that the $94 million invested returned nearly twice that amount, $172 million.

The Carter administration did not appear to know what to do with the space program. The new administration should provide the needed leadership to ensure the American people realize the space program is not just another government expenditure — it is an already successful investment with even greater potential in the future.

Economic studies such as those by Chase Econometric Associates and

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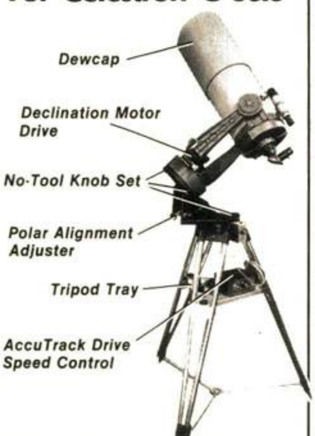

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the Midwest Research Institute as reported by Dr. Harry Dawson (November 1979, *Insight*, publication of the National Space Institute) produced results which are startling:

"NASA research and development (R&D) spending is more economically stabilizing than is general government spending, significantly reducing unemployment and inflation while at the same time adding more than $7 to our country's gross national product (GNP) for each dollar that is spent. In this time of high unemployment and double-digit inflation, it would seem to make more sense to increase NASA's budget rather than those of income redistribution programs that have a much smaller beneficial impact on our economy." (emphasis added)

- To Return the United States to Its Former Relative Energy Independence. It is a modern fact-of-life that mankind is now (for the first time) straining the mineral and fossil energy resources of our planet. We must seek new and reliable sources. Where? The ocean floor? — yes, but only if technology and foreign nations permit. Space? — yes, space offers limitless bounty. The solar system has more resources than we can use in a thousand generations.

To reach the point at which we can massively enrich the Earth with resources from space will require long-term development. With the coming of the Space Shuttle, the Reagan administration has the opportunity to play a historic role in starting this development. At this time, the new administration's primary concern must be to ensure that the private domain is encouraged, through the use of advice and economic incentives, to take advantage of the space environment through the upcoming Space Shuttle. The Shuttle is expected to draw roughly $1 billion per year from its users (not Uncle Sam), ranking it in the middle of the Fortune 500. What more appropriate goal for a Republican administration than to sow the seeds for the private domain to increasingly support the civilian space effort?

- To Ensure a Solid Across-the-Board Military Capability. Already we find that SALT agreements are impossible without ongoing satellite surveillance. Although many hesitate to see us develop military capabilities in space, we may not be able to avoid it. What supplied, for example, our country's primary source of intelligence about the Russian military commitment and movement around Poland and Afghanistan? Satellites did.

- To Restore to the American People Pride in Their Nation. The modern facts of life began to hit home in the Seventies. Global problems, which hit U.S. citizens in the form of inflation and unemployment, hit a growing number in foreign lands in the form of abject poverty and starvation. Projections into the future are bleak, even frightening. Many of our basic economic and social problems appear to be impervious to head-on confrontation. But these, in great part, are due to global problems which require "global" thinking, or a "cosmic perspective" as Carl Sagan has stated.

Economic development of space offers us a chance to overcome social and economic problems with new solutions arising from future technologies, industries, energy sources, and of course, the jobs these would create. New problems will surely arise, but with solution of old problems comes growth for societies as well as individuals. Will we grow, or will our new leadership fail us by limiting our search for solutions in terms of old ways of thinking which only made the world as it is today?

If we fail to act on the future by rejecting the challenge of a "New Frontier," what will happen? As far as I can see, political and social chaos will grow as more people fight over fewer resources, encouraging the rise of Orwellian regimes throughout an overpopulated and resource-depleted world. Or possibly the United States will find itself left in the dust as bolder nations take control of the future. In either case, Americans lose.

As the financially starved Space Shuttle's development sputters along, Europe's Ariane commercial rocket is ready to compete. And I am afraid that the first permanently manned space station, a most important milestone (as publicly stated by Leonid Brezhnev), will not have an American flag on it.

A nation that fails to encourage and support its thinkers and dreamers, its creators and producers is a nation that fails. The potential of space awaits us. President Reagan: Go for it!

Gary E. Mechler
Public Relations Officer
Kitt Peak National Observatory

The Soviet Space Shuttle: What's It For?

Most people, when they think of the name Arthur C. Clarke, think of the film *2001: A Space Odyssey*, based on one of his many novels. Few think of Clarke as a scientist — and yet he came up with both the idea of a communications satellite and, more importantly, in his novel *Prelude to Space*, the concept of the space shuttle as a reusable, airplane-like vehicle. Many years of technological development, bold ideas, and budget cuts have resulted in the present U.S. Space Shuttle design.

But what of a Russian shuttle? The American public first became aware of the Soviet space shuttle on March 20, 1978, when the aerospace news magazine, *Aviation Week and Space Technology*, published a short article describing the major characteristics of the vehicle and stating that it was being drop-tested from a Tupolev TU-95 Bear bomber. In a later more detailed article, this was amended to say that the Soviets have been drop-testing their shuttle since 1975 or earlier!

The Soviets have released very little information about their shuttle — but what little information we do have leads us to believe that it is, in some ways, very similar to the abandoned USAF X-20. This $1 billion project, also called Dyna-Soar, was started about 20 years ago, and was to be undertaken at the same time as the NASA Gemini program, with first launch in 1965 or 1966. Its primary functions were to see if aerodynamic re-entry was possible and to test whether a pilot could remain in control all the way down to the surface and land the craft on a runway.

The ship would have been small — smaller than the famed X-15 supersonic rocket research craft — with a length of 35 feet and a wingspan of 20 feet. Its shape would have been the old delta-wing configuration described by Clarke, though somewhat stubbier than most contemporary designs.

On a typical flight, the X-20 was to be mounted on a Titan II ICBM and launched as a conventional manned payload. Once in orbit, it would have remained attached to the ICBM transfer stage for propulsion, stabilization, and other support. After the mission, the transfer stage engine would have been fired for de-orbit and then separated from the shuttle. Descent would be controlled by a combination of flaps on the wings and thrusters, and landings (at conventional runways) were to be on skids.

The Soviet shuttle, though very similar in concept, is believed to be larger and more advanced. It is smaller than the U.S. Space Shuttle and probably somewhat inferior

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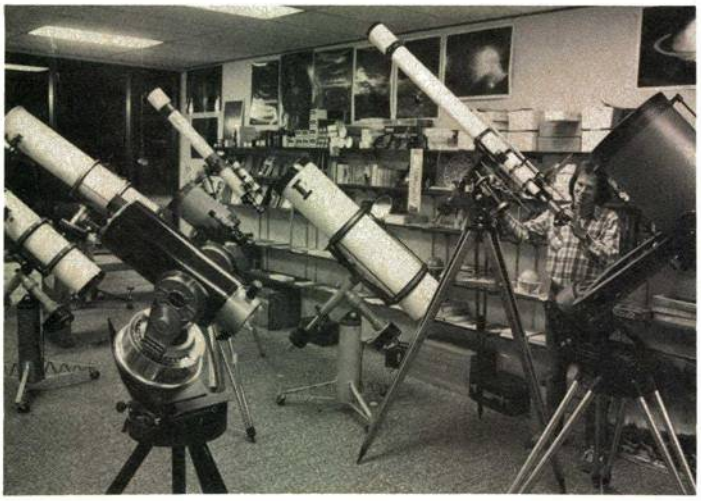

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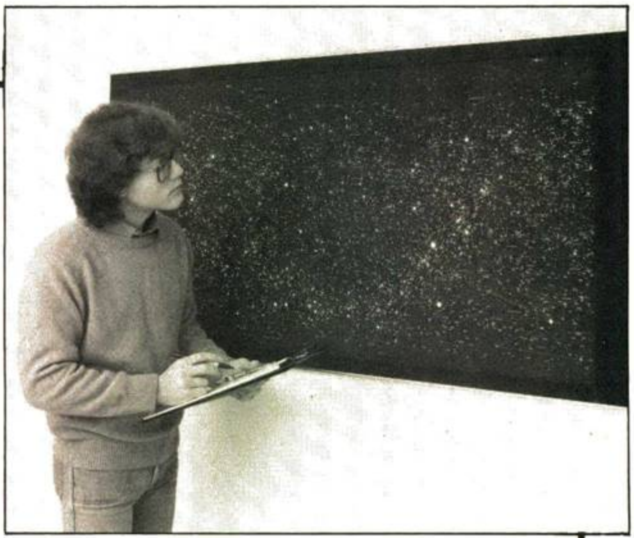

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technologically. Operationally, however, it will be ahead of the U.S. Shuttle in many respects.

The Soviets appear committed to seeing their space shuttle fly. In general, financial considerations do not greatly concern the Soviet engineer. This year the U.S.S.R. will probably launch well over 100 payloads, many of them very heavy. Roughly a quarter of them will be manned or man-related, assuming this year's program is similar to the last several.

NASA

NASA, by contrast, will launch only 14 payloads in 1981, one of which will be manned. All but three are reimbursable by other nations, corporations, or the military. The USAF may launch perhaps the same number, but probably fewer.

Today the Soviets maintain at least five major development programs: their shuttle, space-tug, space station, the Progress cargo transport and tanker, and Soyuz-T three-man transport. All of them are manned or man-related. But NASA is hard pressed to maintain even one: the Space Shuttle. Put it all together and it seems hard to escape the conclusion that the Soviets are spending, at a minimum, three to four times the U.S. space expenditure, i.e., $15-20 billion per year — nearly half the entire cost of Apollo every year! So it appears the Soviet shuttle is bounded only by the limits of Soviet technology, and not by budgetary constraints.

Initially, the Soviet shuttle will launch from atop a conventional expendable rocket (probably a Proton Booster). After re-entry, maneuvering will be accomplished with the aerodynamic shape (probably combining lifting-body properties with delta-wings), and landing will be on a conventional runway.

By the late 1980s, the Soviet shuttle program will involve operations far more advanced than either the X-20 or the Space Shuttle. The Soviet shuttle will be placed upon a winged booster and launch will be horizontal from a conventional runway. We don't know whether this booster will use rockets, air-breathing engines, or both. When a large fraction of orbital velocity has been attained, the shuttle will separate from the booster and continue on into orbit. The booster, meanwhile, will glide back to a landing at a conventional runway. The key point is that all operations can be conducted from a conventional runway. Both the booster and the shuttle should be totally reusable and in full service by the late 1980s.

This is the shuttle that Clarke and company used to dream of. It is similar to the design *originally* proposed for the U.S. Space Shuttle which, for budgetary considerations, was cut down to the partially reusable system we now have. The Soviet shuttle concept would be quite a challenge for U.S. industry, and it remains to be seen whether the Soviets can complete the work required on the time scale they have projected.

But what is the role of the Soviet space shuttle? Two things suggest that it is largely military in nature. First, the ability to conduct all operations at conventional runways. This reduces the possible payload, but is a tremendous military advantage. The U.S. Space Shuttle must launch and land at either Cape Canaveral or Vandenberg AFB. The destruction of both these places would destroy American access to space. The ability to launch and land from any airport makes it almost impossible to deny the Soviet shuttle access to space.

Second, because of their wings, shuttles have a wider choice of landing places once they re-enter the atmosphere and have a larger re-entry window for a given landing area. Thus pilots have much more control over their craft than in conventional ballistic space craft and would be much harder for potential enemies to locate. These benefits were stated by the USAF in support of the X-20 — suggesting that the Soviets may be thinking along similar lines.

Furthermore, the size of the Soviet shuttle implies some specific types of missions and eliminates others. It seems very unlikely that the Soviet shuttle has cargo doors, so its purpose must be very different from the U.S. Space Shuttle. It will not deliver satellites to orbit, nor recover them for repairs. The Soviet's primary interest in space exploration appears to be space station development. It seems logical to assume that their shuttle is intended to deliver men and supplies to such stations. Their shuttle, small but able to make frequent inexpensive launches from anywhere in the country, appears admirably suited to the task. This was also one of the tasks envisioned for the X-20.

Another important reason for the Soviet shuttle is probably budgetary. By the end of 1980 and the return of the three-man Soyuz-T-3 mission, the Soviets had launched 28 vehicles to Salyut-6. Fourteen of them were manned Soyuz, three of them were advanced Soyuz-Ts, eleven were Progress tanker-transports, and one was the Salyut-6 booster itself. All this must have been incredibly expensive. Since a reusable shuttle would allow each ruble to go much farther (even if those rubles are virtually unlimited), lowering the cost would be worthwhile as the technological capacity and hardware now being used to build expendable launch vehicles could be applied to projects in space.

Why do the Soviets put so much emphasis on space stations? Strangely enough, they have made no real effort to hide the answer from us: they want to learn to live and work in space. While all U. S. programs have been single-goal oriented (e.g., Apollo), the Soviets are attempting a general program aimed at learning how to keep men and their machines functioning in space. Their program is far less spectacular than ours, but in the long run they will probably accomplish far more with it. They have learned to pursue long-term goals.

And what *are* these long-term goals? Again the Soviets have made no real attempt to hide them: they stated twice during the second Salyut-6 mission that they plan manned planetary missions in the near future, with Mars as their first goal. By attempting this much more difficult mission first, they will avoid any political commentary on being second to the Moon. And if they try a Mars mission any time within the next ten or fifteen years, they will get there long before we do.

In the very long term, I believe that the Soviets intend to dominate space. There seems to be no other reason for spending such vast sums as they now are. And such a program could have very definite political and economic advantages. The Soviets do not appear to have the dislike of long-term goals that the U.S. does, and this pursuit of long-term goals could eventually be decisive in the struggle to control the world — superior American *technology notwithstanding.*

Donald F. Robertson
Sacramento, CA

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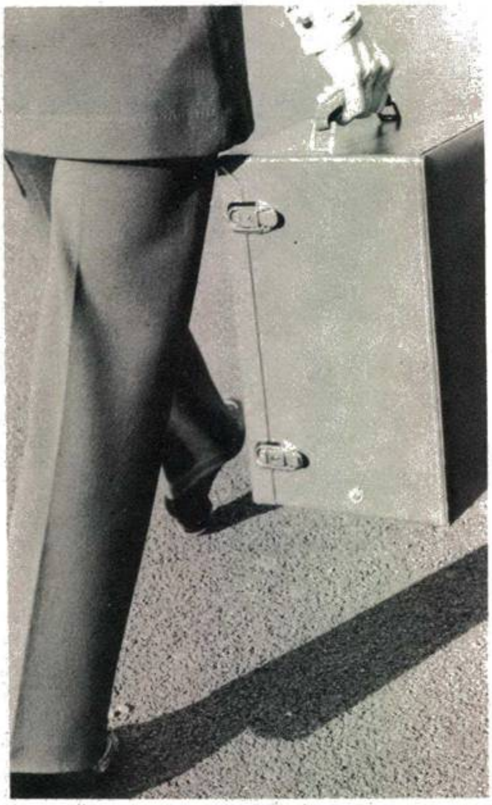

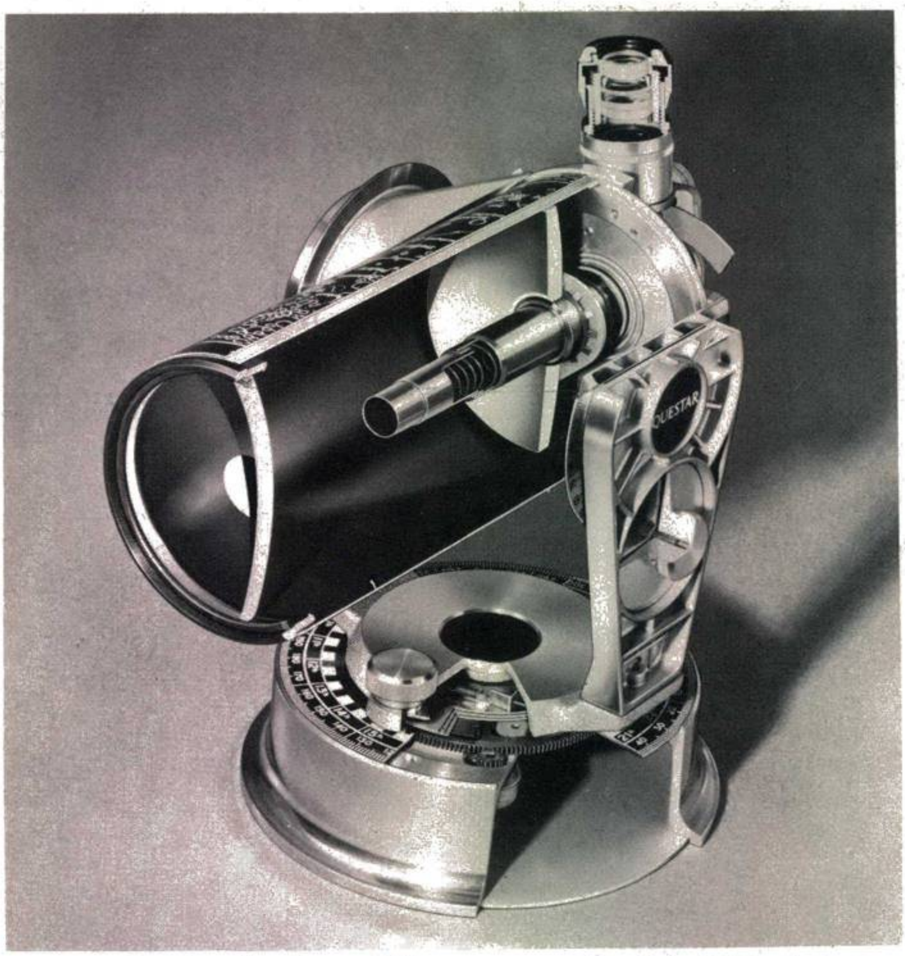

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eye
on the
sky

the beasts of spring

by Fred Schaaf

the wanderers

Jupiter and Saturn, which only recently treated us to a performance of their extremely rare Great Conjunction, also lead off this month's highlights. These glowing bodies (the only bright planets visible, due to the others' proximity to the Sun) have moved only a bit apart and will shine brightly into the night.

As an added bonus for observers, the April sky will afford a view of a breathtakingly slender Crescent Moon. And, among other solar system delights, a fascinating (though unobservable) alignment of the planets will occur this month.

During April, **Jupiter** and **Saturn** move west among the stars almost to the farthest they will reach on their "retrograde loops." The faster-moving Jupiter increases its separation from Saturn to several full degrees, but neither of them declines much from the maximum brightnesses (-2.0 and 0.6) they achieved in the last days of March when both were at opposition. At the beginning of April, Jupiter is near Eta (η) Virginis, and at the end of the month, it is Saturn which is close to this 3.9 magnitude star.

Because they are passing near the Sun this month, **Venus** and **Mars** will not be seen and their close (42′) conjunction with each other on April 4 will be missed. The interesting thing is that Mars has its conjunction with the Sun on the 2nd and Venus follows on the 7th, so these three celestial objects form a remarkably compact triangle during this period. But what is really unusual is the pattern which the trio forms with Jupiter and Saturn. Since those two planets were almost directly opposite the Sun on March 26, April opens with an amazing arrangement of no less than six major solar system bodies in a nearly straight line in space.

The line consists (starting at the far side of the solar system) of Mars, Venus, Sun, Earth, Jupiter and Saturn. Among the bright naked-eye planets, only **Mercury** is well out of this arrangement, still over 20° from the Sun as April starts but ever lower in the east before sunrise as the month progresses, and poorly placed for northern hemisphere viewers. Not until April 27 does Mercury creep in to be at superior conjunction with the Sun. But by that time the members of the line will have drifted apart.

This arrangement must be very rare indeed, but we should not exaggerate its significance. For one thing, although all of the bodies involved are within just a few degrees of the line, that is still rather far from perfection. Several years ago a book appeared claiming that in the early 1980s many of the planets would line up on one side of the Sun and, by a series of unproven links, produce quakes and weather disturbances on Earth. In his refutation of this supposed "Jupiter effect," Jean Meeus pointed out that there is no such line-up of planets — instead of having disasters, we have in successive years (1980 and 1981) much beauty from the sights of just two planets at a time together at opposition and thus nearly aligned with Earth and Sun. In 1980 Mars and Jupiter were together, but before Jupiter could catch up to Saturn, Mars had moved far on.

As a final curiosity, notice that our current "line-up" occurs quite near the beginning of spring, so Jupiter and Saturn must be near an equinox point (where the ecliptic, apparent path of the Sun, crosses the celestial equator). And this is so: during April, Jupiter and Saturn nudge north just over the celestial equator (they now together pass directly overhead in Ecuador and Kenya), and on April 1 while the Sun, Venus, and Mercury set almost due west, Jupiter and Saturn are rising just above the due east point.

This year the Lyrid meteors reach maximum on April 22, but are spoiled by a nearly full Moon. However, there is another fine solar system sight in addition to the continuing Jupiter-Saturn show. If your skies are clear on the evening of April 5, you have an excellent chance to see an unusually "young" **Moon**. At sunset that night, eastern U.S. observers can find the crescent about 12° above the western horizon, and just 27 hours old (age is the amount of time since New Moon). Western U.S. viewers will see a slightly higher Moon still only 30 hours old. (You may need binoculars to pick it out.)

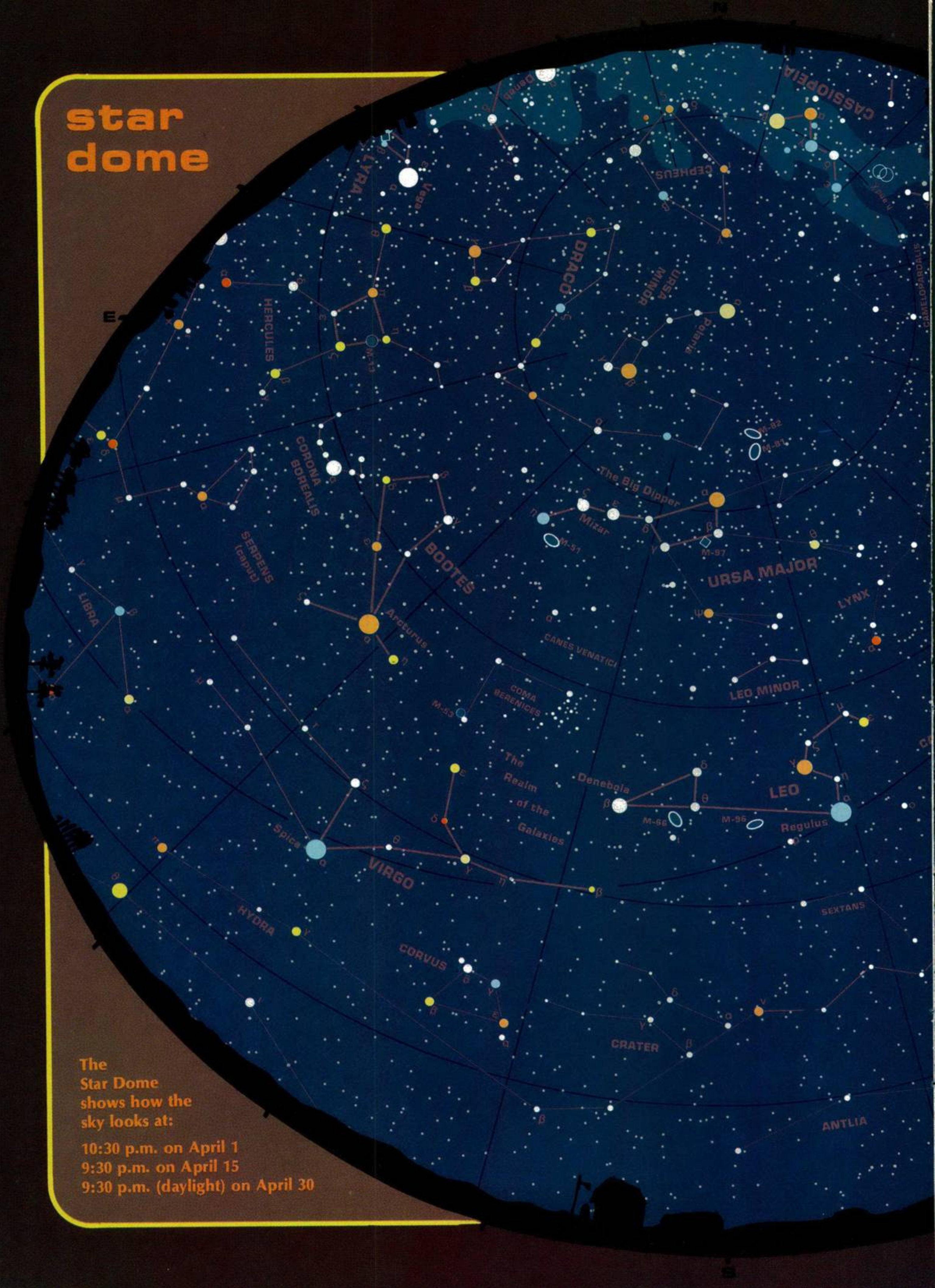
Such a Moon has been glimpsed by very few people, because it requires fairly unusual astronomical conditions combined with good weather. But the sight is well worth the wait and effort — most of us have seen, if only by accident, a 40, 50, or 60-hour-old Moon and thought it a beautiful sight, but a young Moon like the one of April 5 is an unbelievably delicate sliver, a glowing, curved filament afloat in the sea of the Sun's afterglow as evening deepens. If you are a photographer, try to capture this delicate wonder. If the weather is bad, the next night's Moon will still be unusually lovely, little more than two days old, and higher in the sky.

the starry sky

On spring evenings at the latitude of the United States, the northern and southern shoulders of the sky are brightly burdened with two giant constellations which represent large beasts. The star-formed animal due

The penumbral lunar eclipse that happened early on the morning of January 20, 1981 was a striking sight. At mid-eclipse, as Christian Pierson's photo shows, the northern limb of the Moon was a dusky grey. (To view the photo in its true scale, look at the page from a distance of about 54 feet.)

star dome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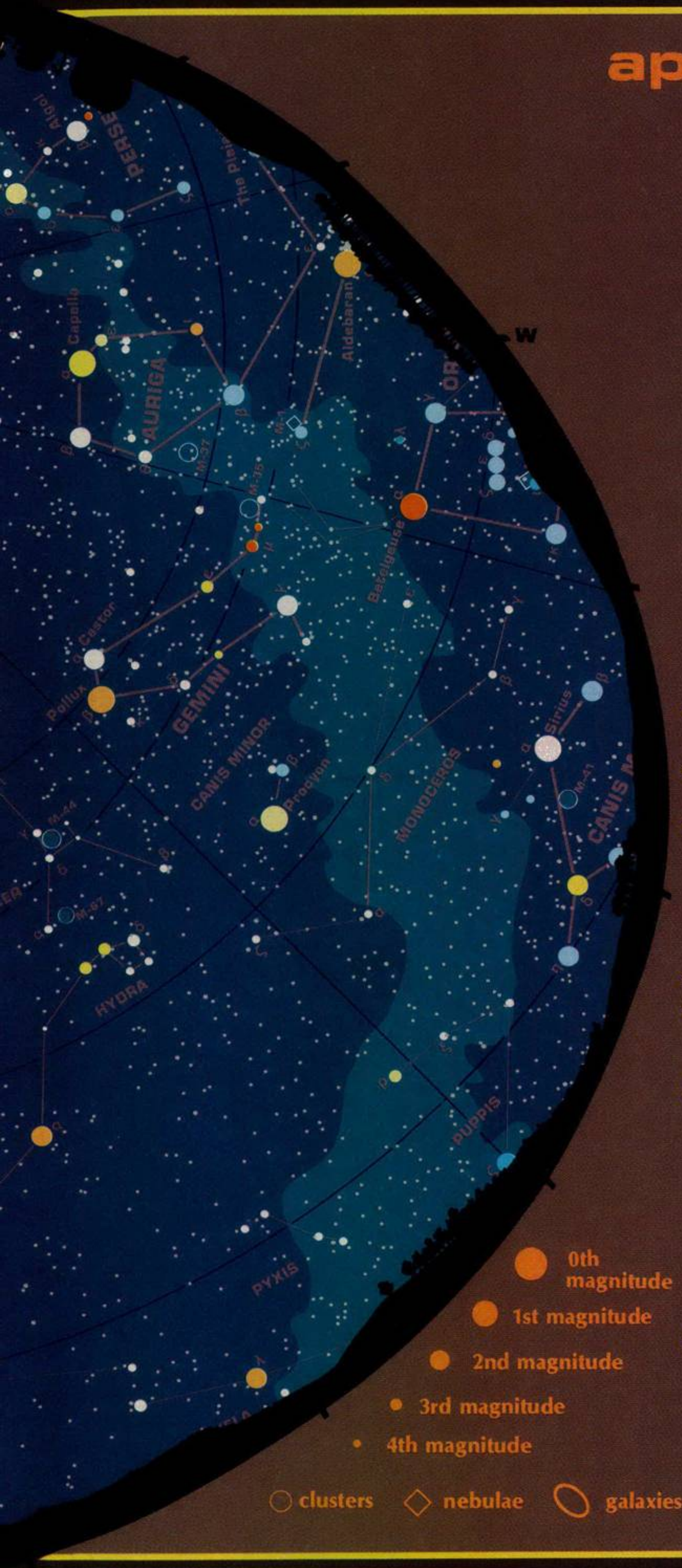
M-13
CORONA BOREALIS
SERPENS (caput)
BOOTES
Arcturus
The Big Dipper
Mizar
M-51
M-82
M-81
M-97
URSA MAJOR
LYNX
CANES VENATICI
LEO MINOR
COMA BERENICES
M-53
LIBRA
The Realm of the Galaxies
Denebola
M-66
M-96
LEO
Regulus
Spica
VIRGO
SEXTANS
HYDRA
CORVUS
CRATER
ANTLIA

The Star Dome shows how the sky looks at:

10:30 p.m. on April 1
9:30 p.m. on April 15
9:30 p.m. (daylight) on April 30

april sky almanac



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CANIS MINOR
Procyon
MONOCEROS
Sirius
M-41
CANIS M
M-44
M-67
HYDRA
PUPPIS
PYXIS
0th magnitude
1st magnitude
2nd magnitude
3rd magnitude
4th magnitude
clusters
nebulae
galaxies

2nd Just before sunrise, look for Mercury near a very slender Moon, low in the east-southeast. Also: the Sun overtakes Mars at 9 a.m. EST today, shifting the planet from the evening sky to the morning sky — but you won't begin to see it there until early June.

4th New Moon at 3:19 p.m. EST.

5th Moon at perigee (closest to Earth) this afternoon: 222,760 miles.

7th Venus passes "behind" the Sun at 4 a.m. EST this morning, thus changing from the morning to the evening sky. It will start appearing in the west after sunset by late May.

11th First Quarter Moon at 6:11 a.m. EST.

12th Pluto reaches opposition to the Sun this evening.

16th At about 8 p.m. tonight, the Moon (gibbous in phase) will pass north of Jupiter. Some five hours later (around 1 a.m. on the 17th), it will pass north of Saturn.

19th Full Moon at 2:59 a.m. EST.

20th Moon at apogee (farthest from Earth) this morning: 252,484 miles.

21st Tonight, and during the pre-dawn hours tomorrow, the Lyrid meteor shower will be at its peak activity. Look for 5 to 10 bright meteors an hour coming from the part of the sky between Lyra and Hercules. But beware: strong moonlight will decrease the numbers you'll see.

27th Last Quarter Moon at 6:14 a.m. EDT. Also: Mercury is at superior conjunction at 12 noon EDT today, passing the Sun on the far side. This means it moves from the morning sky into the evening sky. You'll find it there early in May.

south of the zenith at mid-evening is **Leo** the lion, while the creature high in the north is **Ursa Major** the great bear — whom we know best by the part of him called the **Big Dipper**.

In the middle of April evenings the famous Big Dipper is at its highest, directly above Polaris which shines right beside the north celestial pole. The Big Dipper is close enough to the north celestial pole never to set, and if you know what the month or season is, you can tell the time of night by noting the position of this pattern. You can also, of course, find true north by running a line up through the "Pointers," the outside stars of the Big Dipper's bowl, and extending it until you reach a bright star, which is **Polaris**. At our current viewing time, the Big Dipper is inverted, so "up" from the imagined bowl would be straight down to the North Star.

If you know your constellations fairly well, you can figure out both where you are and what time it is by looking at any part of the night sky. That ability can actually be of serious practical value on infrequent occasions, but it is always rewarding to have a better picture of your own place in the universe (both on this Earth and amongst the awesome fields and paths of the stars).

The Big Dipper is, of course, far more than just a compass-needle or the hand of a sky clock — when have you ever seen a street sign or a navigational beacon as beautiful and grand as these seven stars? One of the stars is a lot dimmer, but the others all shine at magnitudes between 1.8 and 2.4. An interesting project is to go out and estimate the magnitudes, or at least rank them from brightest to faintest. (Answers: Alpha [α] 1.95, Beta [β] 2.44, Gamma [γ] 2.54, Delta [δ] 3.44, Epsilon [ϵ] 1.68, Zeta [ζ] 2.40, Eta [η] 1.91.)

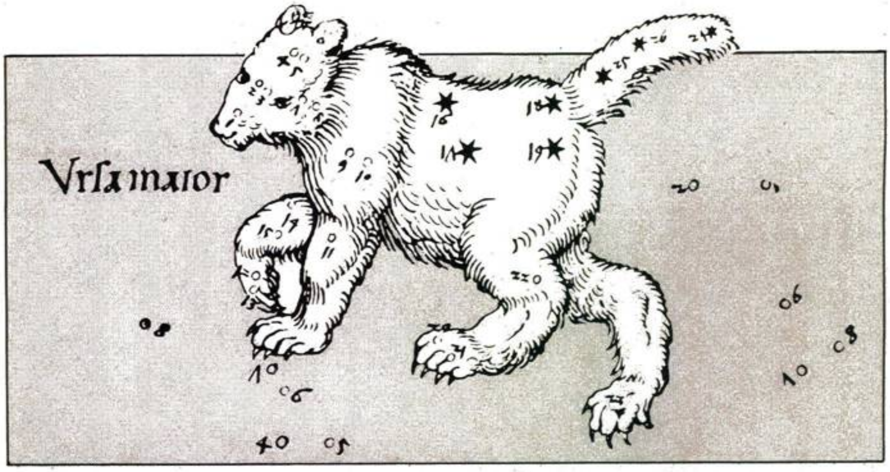
The Big Dipper is only a small part of a vast star-creature — it forms the tail (Dipper Handle) and the hindquarters (Dipper Bowl) of Ursa Major. Most of the other stars of the great bear are not noticed by novice skywatchers, but no less than three of them are brighter than Megrez, at magnitude 3.3 the dimmest member of the Big Dipper. Ursa Major is clearly a very fine constellation across all of its enormous extent.

Its more compact (but still huge) rival, high in the southern sky, contains another famous asterism. The front half of Leo is composed mostly of the **Sickle**, a 16° tall hook of stars which includes **Regulus**, literally the "little king" of the king of beasts. Second brightest star in the Sickle is **Algieba** and at the eastern (posterior) end of Leo is 2.1 magnitude **Denebola**.

Shimmery curtains and arcs mark the light shows of aurorae. Because they are seen so infrequently, their visual effect is all the greater. Randy Trank took this photo with a 2-minute exposure at f/2 on 100 ASA slide film (using a 50 mm lens) and then duplicated the slide to boost contrast and enhance the colors.

As a constellation of the Zodiac, Leo was the home of three bright planets at one time during 1980. By comparison to last spring, the lion now seems a little dimmer, but he blazes relative to **Cancer** the crab just to his west. Cancer's center is formed by two stars which are called the **Aselli** (the asses) because they were pictured as these beasts coming to the **Praesepe** (manger) between them. And that Praesepe is **M-44**, the **Beehive Cluster**, which is easily visible to the naked eye and superb in any binoculars.

Still farther west, the twin stars of **Gemini, Pollux** and **Castor**, and the star **Capella** form the still fairly high top of a giant arch of winter stars which sink ever more into twilight as April *progresses*. Meanwhile, under Cancer and Leo, the long twisting shape of **Hydra** the sea serpent slithers with its



orange heart, **Alphard**. Can you detect the color of this 2.0 magnitude star with your naked eye? Use the spectral colors in the Star Dome as a rough guide in an attempt to see which seem colored to your unaided vision.

Sitting on top of a southward sag of the sea serpent's coils are **Corvus** the crow and **Crater** the cup. These two are linked in legend and often spoken of together: even the sounds of their names flow together harmoniously. Corvus is a prominent little pattern of third magnitude stars, but you will need relatively dark skies or excellent vision to make out clearly the faint form of Crater.

The Big Dipper's handle can be extended in a curve to reach brilliant **Arcturus**, which shines in kite-shaped **Bootes** the herdsman. But this star and its constellation are still on the rise in April, so we will take a longer look at them next month, when we will also study **Spica** and its large constellation **Virgo** the virgin (in which Jupiter and Saturn now reside). Just above Virgo's head and Leo's tail is a strange but beautiful little patterning of dim stars — like an irregularly hanging necklace of sparkling gems in dark skies. This is **Coma Berenices**, or rather the Coma Cluster which forms the most interesting part of the constellation. Coma Berenices is "Berenice's hair" (though before Queen Berenice of Egypt it had been the tuft of Leo's long twirling tail). Here, through the locks of Berenice and all about the head of Virgo, floats a cloud of innumerable galaxies. They are too faint to see with the naked eye, and too distant truly to comprehend — as if they were the dreams of the two star-maidens who are honored with constellations here in this part of the spring skies.

skylore

Ursa Major, the giant lumbering bear of the North, looms as large in legend as he does in the sky. There are a tremendous variety of myths about this constellation, but what is most interesting is how many cultures around the world have pictured a bear among these stars (though not always with the same individual stars) — and how many cultures have had to account for the absurdity of a celestial bear with a most unnaturally long tail.

How did the bear come to be identified with these stars all over the world, in cultures apparently isolated from each other? This mystery is even more fascinating and puzzling than the widespread tale of the Lost Pleiad. It is conceivable that the American Indians might associate some or all of the prominent Big Dipper with the bear which many of them most respected — the most important star pattern could logically represent the most important animal. But there would seem to be no particular reason why the Greeks and so many other cultures should find a bear here. The existence of the inappropriate tail makes it look as though the Greeks and other peoples were following an old tradition which had become confused but which lingered and had to be explained (with special stories to account for the long tail) even though it was really just a mistake.

The most scholarly theory points out that the Sanskrit term *Riksha* means in one gender "bear," but in another, "star" or "to shine." So it is possible that a title (presumably used in India) — "the Seven Shiners" — could have later been mistaken by speakers of other languages for "Bear." This is a clever idea — but perhaps too clever. Maybe a simpler explanation is the true one. If so, that true explanation surely has nothing to do with Aristotle's comment that a bear in the northern sky is fitting because only such a creature could survive in the cold lands of the north. Aristotle's idea is an imaginative afterthought, certainly not the kind of idea which would have been manifest to many people in many cultures or likely to compel them to name these stars a bear.

Ursa Major as we now draw him contains a great deal more than just the familiar Big Dipper, but apparently this too is not a modern idea. Although Homer's Ursa Major was apparently limited to the famous seven stars, the tradition of a much more extensive bear in this region may be even older than Homer and could possibly have been borrowed from very ancient Mesopotamian sources. The Greek word for "bear," by the way, was *arktos*, which is the source of our word "arctic" (as well as the name of the bright star Arcturus), so Arctic explorers are people who investigate those regions where Ursa Major (and, of course, Ursa Minor) shine high overhead.

The stars of Ursa Major — usually the ones of the Big Dipper — have also been called a wagon or wain in many cultures down through the ages. Homer referred to "the Great Bear, by others called the Wain" and Aratos wrote of the "Wain-like Bear" (which further hints that the Greeks' use of bear was really derived from a confused tradition, rather than what they naturally imagined the pattern to resemble). In Britain, of course, the Big Dipper is known as the Plough and as Charles' Wain, supposedly after Charlemagne. But in the days of early Britain, the name was Arthur's Wain after the famous (but mostly legendary) ruler. King Arthur was closely associated with these seven stars in the old legends — the name Arthur may well be from the Welsh *arthuthyr* which is "bear wonderful."

The bear has indeed been a highly venerated animal in the thoughts of all people of Northern Europe, and it was not unusual to compare a warrior with the animal, as is shown by the still popular Scandinavian name *Bjorn*, "bear." Our word "berserk" comes from the *berserkers* of Norse days, fearsome warriors who went into uncontrollable rages (sometimes biting their shields) when they dressed in bearskins ("berserk" is "bear-shirt"), supposedly taking on the nature of the animal. Despite all this, however, the Norse and other Teutonic peoples did not see a bear in the very unbearlike seven stars — they called it the great wagon.

If these Teutonic peoples who lived with and revered the bear did not see it in our Ursa Major, then perhaps we cannot assume that it was natural for the American Indians either. Could the idea of the great bear have actually spread to the New World — or from the New World — in ancient times? That seems unlikely and unnecessary to assume, as will be clearer next month when we look at the American Indians' rich myths for these stars. And we will also consider the lesser bear, our Polaris-bearing Ursa Minor, who is well-placed in May but difficult to separate from his huge companion.

ASTRONOMY IN FOCUS

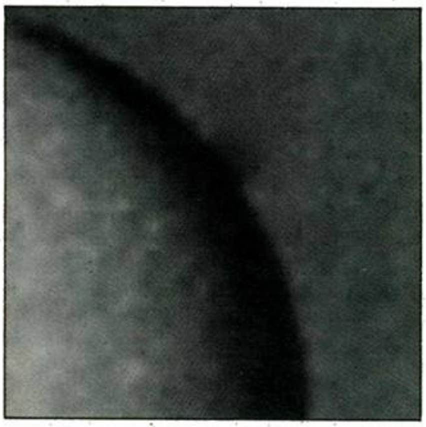
Spots Before My Eyes

Sir / I am writing in regard to the picture of Dione on page 20 of your January issue. Is that a volcano on the shadow side?

Tom Chase
Green Belt, MD

Mr. Chase / No, it's not. The television cameras aboard the Voyager spacecraft have a regular array of reseau dots coated on their faces so that camera electron beam distortions can be rectified. After this step, a computer program often "fills in" the reseau dots with the average value of the pixels around it. Usually, this makes the dots nearly invisible.

When a dot happens to be at the boundary of a light and dark area in the image, the computer colors it an average gray tone. On the Dione image, this looks like a volcanic plume. Examine the Voyager Jupiter and Saturn pictures closely, and you'll see plenty of reseau mark "scars."



JPL/NASA

Saturn's Ring Divisions

Sir / After Voyager 1 sent back pictures showing the large number of subdivisions in Saturn's rings, many scientists expressed utter amazement. I would like to point out that past observers of Saturn (many of whom were amateurs) saw subdivisions in Saturn's rings and drew them as such. (All of this is recorded in the excellent book *The Planet Saturn* by A.F.O'D. Alexander, lately reissued by Dover Publications.)

Chapter 11 has the title "Elusive Subdivisions in the Rings." On December 17, 1825, Henry Kater observed Saturn with a 6¼" aperture telescope and noted several divisions in the A ring. A drawing of them appears as Plate IV, Fig. 2.

Subsequent observations by various people during the 19th century added support. Included among the observers were Encke, De Vico, Dawes, and Lassell (who all observed the north face of the rings from 1833 to 1848), and Dawes, Lassell, Tuttle, Jacob, Secchi, and Coolidge, who observed the southern face of the rings from 1849 to 1861.

Dawes, observing the rings from 1854 to 1855 with a 7½" Clark refractor, found ring B "decidedly in stripes." On March 20, 1856, Coolidge saw four or five narrow divisions in ring B. Alexander concluded at the end of this chapter that because so many subdivisions had been noted, no true gaps in fixed positions were present.

Part of Chapter 21 deals with a "New Outbreak of Division Finding, 1897." Divisions such as Antoniadi's in ring B were seen. On June 15th, 1897, Fauth, using a 7½" refractor, saw Encke's division, ring B divided into three parts, and ring C divided from ring B by a distinct dark shading. Even Percival Lowell noted subdivisions in 1914 using the 24" refractor at Flagstaff.

Walter H. Haas, editor of *The Strolling Astronomer* (the Journal of the Association of Lunar and Planetary Observers), noted subdivisions in the rings in the 1940s. And finally, Bernard Lyot, using the 24" refractor at Pic-Du-Midi, drew numerous subdivisions in the rings in 1943. A drawing of his appears as Plate XVII, Fig. 2 — to me, it looks remarkably similar to the Voyager photographs.

Yet all of these observations were rejected in 1954 when Gerard Kuiper, using the 200" Hale reflector with a power of 1,170, observed the rings and concluded that only one division existed, Cassini's division. I quote from page 420: "The importance of this observation and pronouncement by one of the world's leading planetary observers, using the world's largest telescope, is self-evident, and clearly refutes any idea that may exist of there being any gap through the rings other than Cassini's division."

Amateur observers, observing at the limit of their telescopes, were certainly wrong when they drew canals on Mars, but it seems as though many who saw and drew subdivisions in the saturnian rings have been proven correct by Voyager. There are indeed numerous divisions and subdivisions!

By the way, any Saturn buff ought to have a copy of the Alexander book. The observational history of this planet is fascinating.

Jim Phillips
Charleston, SC

Student Space Society

Sir / An intercollegiate society, Students for the Exploration and Development of Space (S.E.D.S.), has been formed, its first chapters having been established at M.I.T., Princeton, and Yale. The steady deterioration of the United States space program's goals and budget endangers our future and demands an organized response from our nation's campuses. The society's ultimate goal is to establish itself as a national student pro-space organization. We invite you and the students of your college to begin a chapter, and join us in our cause.

Our immediate plans include submitting petitions to Congress and the President urging the restoration of the Solar Power Satellite research budget. If you are interested in forming a chapter at your college and helping in these efforts, please write to us for further information:

Peter H Diamandis
M.I.T. Chapter of S.E.D.S.
372 Memorial Drive
Cambridge, MA 02139.

The collegiate population of the United States must unite in the common goal of exploring and developing our only endless resource: space. Join us.

Keeping Warm I

Sir / Living in Michigan, I have had considerable experience with cold weather observing. I have a suggestion to add to Art Huffman's ideas for keeping warm (ASTRONOMY, December 1980). I can observe for periods of up to two hours by wearing a ski mask under a motorcycle helmet. It sounds weird, but think about it: a helmet consists of an inch or more of foam rubber, air spaces, and fiberglass — all excellent insulators! By minimizing heat loss through your head, you do help keep the rest of your body warm, just like Mr. Huffman says.

If you're worried about how you look, cover it with a parka hood or stay in your backyard while observing. But give it a try — it works great.

Russell V. McDonald
Livonia, MI

Keeping Warm II

Sir / Art Huffman addressed himself to one of the most difficult problems observers in our area have. One part of that problem is keeping your hands warm. If you wear gloves or mittens thick enough to be warm, it's not safe to handle eyepieces, and making notes is very clumsy.

For several years, I've been using a sheepskin muff and "Hob-Nob" cotton gloves. These lightweight gloves have little plastic dots so I have a positive grip on eyepieces, pencils, and telescope controls — and I keep my hands in the muff most of the time for warmth.

A rope through the muff is used to hang it from my neck. I'd suggest a muff about 18" long and large enough inside for both hands, but not so large cold air gets in. I have found that a large bath towel can adequately replace the muff, but it's not as cozy.

"Hob-Nobs" are available from some grocery chains, garden shops, and some drugstores in our area.

Harold J. Stelzer
River Forest, IL

Strange New Wor(l)ds

Sir / In the same spirit of patience, kindness, and understanding which characterized briefings from scientists at JPL, I must say a word about their pronunciation of the names of Saturn's strange new worlds. It came to mind when I heard a well-known scientist turned media star calling Io (pronounced EYE-oh), EE-oh and was reinforced by a disconcerting number of mispronunciations of such words as Enceladus, Tethys, Mimas, etc. Such errors ring harshly on the ears of one with a classical education.

Thinking that perhaps I had not kept up on current variations in acceptable pronunciation, I checked this matter out in one of the most permissive and popular dictionaries of modern American English. No variations are possible: MEE-mas does not exist; MY-mas does. TEH-thees does not exist; TEE-thiss does.

Thus, here is a list of the only correct pronunciations of the recently explored saturnian moons:

MY-mus for Mimas
En-SELL-uh-dus for Enceladus
TEE-thiss for Tethys
Die-OWN-ee for Dione
REE-uh for Rhea
Eye-AA*-puh-tus for Iapetus
FEE-bee for Phoebe.

Fortunately, I have heard no one call Titan (TIE-tan), TEE-ton!

*(AA as the "a" in rabbit.)

John Mood
San Diego, CA

Note

The 1981 *Astronomical Almanac* (successor to the *American Ephemeris and Nautical Almanac*) contains some errors. On page A7, the visual magnitudes listed for minor planets are completely erroneous. On pages G1 to G9, all minor planet positions are apparent, not astrometric as stated. And on pages G10 to G12, the column labeled "longitude of perihelion" should be "argument of perihelion."

Ooops

On page 51 of the December issue, Danny Sagstetter's name was spelled incorrectly. Our apologies.

behind the scenes

cuts in planetary exploration

Rumors about the NASA budget are flying thick and fast as we prepare to go to press with our April issue. Although we won't know for certain until President Ronald Reagan presents his budget proposals to Congress on February 18, it appears that NASA's budget will be cut by roughly 10% — $629 million in the total budget of $6.7 billion. According to "official rumor," the Space Agency plans to make about half the cuts — about $300 million — from the Office of Space Science budget of $756 million. It appears that planetary exploration ranks lowest in priority.

There will be no new starts. The Venus Orbiting Imaging Radar (VOIR) mission will be deferred. The Galileo mission to Jupiter, a project underway since FY80, will be canceled. There will be no American mission to Comet Halley.

The Gamma Ray Observatory satellite will not be started.

However, the Space Telescope, at least according to the rumors we've heard, will be continued. So will the Space Shuttle, now a military necessity. Although it consumes a third ($2.2 billion) of NASA's total budget, the Shuttle will escape with relatively small cuts: the fourth orbiter will be deferred and acquisition of parts for the fifth orbiter will be cut.

What do such cuts mean to people in an organization that has already starved for a decade? "These are cuts in muscle and bone," said one scientist, "because there's no fat left in NASA. And it will utterly destroy the planetary research team." The 4½ year hiatus in American planetary exploration could extend much longer.

Sincerely,

Richard Berry

Richard Berry

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hypersensitizing, part 1

photography
in
astronomy

by
Roger Sliva

If you are a beginner in deep-sky astrophotography, the time necessary to expose your film may seem like an eternity. Bent over, or balancing on a ladder with your eye glued to a guide eyepiece and wondering which way your guide star is going to move next can be extremely tiring. If there were a way to shorten exposure times, you could take more — and better — pictures in the same amount of time.

One of the reasons deep-sky exposures run so long is reciprocity failure — film's habit of "pooping out" on long exposures at low light levels. A film that's "high speed" turns out to be "low speed" when exposed on a dim nebula.

Are there any ways to reduce the time necessary to take an astrophotograph? Of course there are. The most obvious is simply to use a faster film. But the problem here is that a faster film will be much more grainy — you can get the picture in less time, but the grainy prints you'll get will be lower quality than those obtained with a slower, finer grained film. Besides, you may already be using the fastest film available. Alternatively, special "push-processing" can result in an increase of a film's effective speed, but contrast is usually unacceptably increased.

Another technique to increase the effective film speed, which has been very popular in recent years, is using a cold camera to chill the emulsion. But cold cameras are challenging to handle and operate, and in most you have to load each separate frame of the film into the camera individually — a delicate and time-consuming process.

The Trifid Nebula on hypersensitized Ektachrome 400. Photo by the author.

Hypersensitization

Finally, there's an amazing and revolutionary technique called hydrogen hypersensitizing, which not only increases film speed, but also has other benefits.

During the last decade, professional astronomers have managed to shorten their photographic exposure times by exposing film to various gases to sensitize emulsions and minimize low-intensity reciprocity failure. The idea is to replace the water and oxygen in and around the emulsion with another element. Two of the most promising gases, nitrogen and hydrogen, work with varying degrees of success.

To hypersensitize the emulsion, films are "soaked" for a few days in each substance — first nitrogen and then hydrogen. But there's a big problem with this — the so-called "Hindenburg Syndrome." Highly explosive hydrogen is dangerous! You could use nitrogen alone, but results with this "safe" gas aren't as impressive without the smaller molecules of hydrogen.

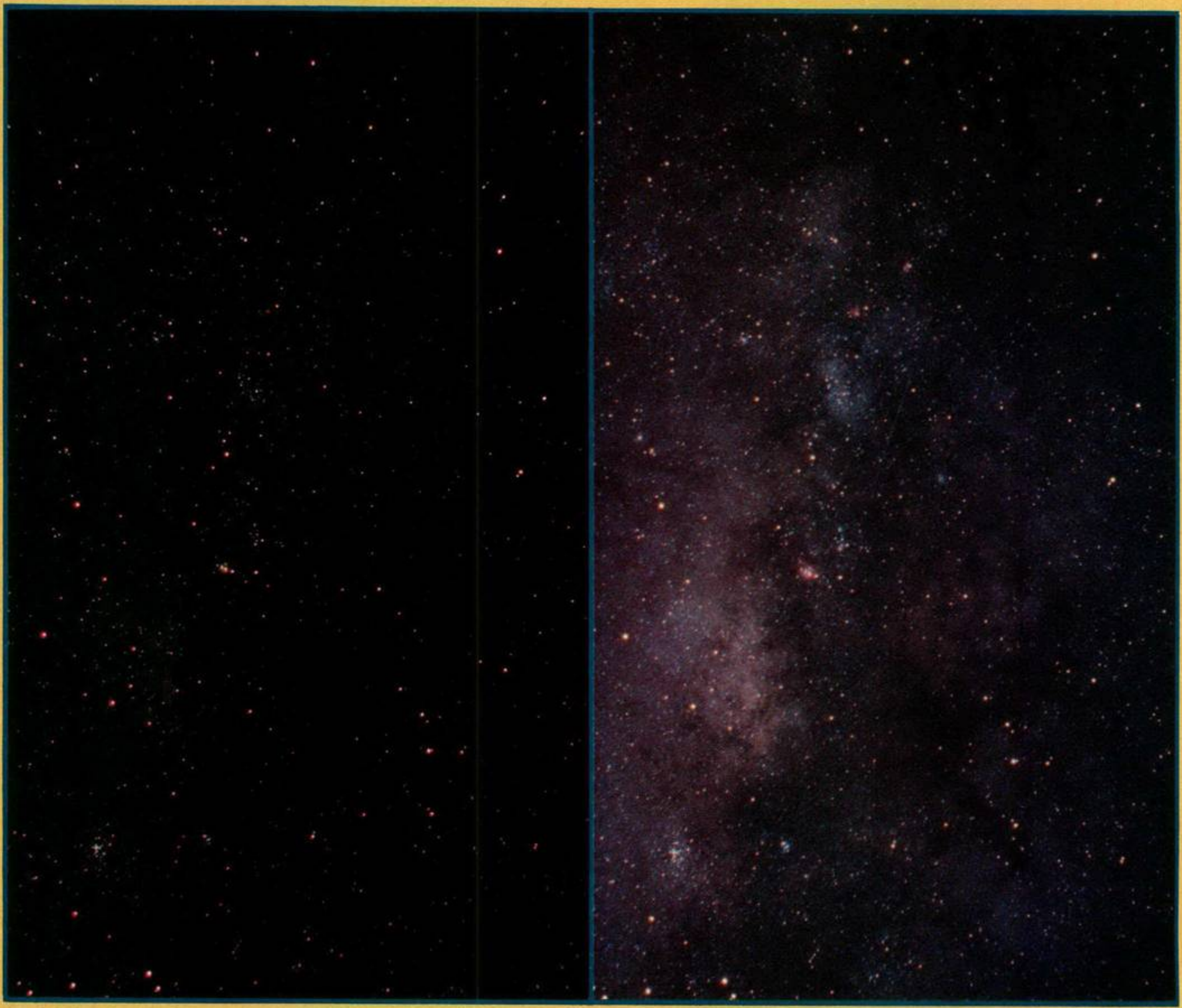
The most recent process is hypersensitization with "forming gas" — an industrial term for a mixture of nitrogen and hydrogen. Forming gas typically incorporates about 8% hydrogen, and testing indicates such percentages are quite effective.

WARNING: Although the percentage of hydrogen in forming gas is low and relatively non-explosive, tank pressures are high and care must still be exercised!

You can purchase forming gas already made, or a bottled gas or welding supply company can mix it for you. The gas to fill a 122 cubic foot cylinder (enough to last one person many years) costs about $22, but the cylinder (about eight inches in diameter and four feet high) will run from $110 to $120. If you order an 8% hydrogen mixture, there may be as much as a 2% error. Since it will cost an additional $50 for a lab test to determine the exact proportions, your initial investment could easily reach $200.

Hypersensitizing is basically a simple process. You place the cassette in an airtight chamber and slowly evacuate the air with an air pump. Then admit the forming gas to a pressure of 15 P.S.I. and allow the film to "soak" for three days at 30° C.

You'll have to experiment with pressures, times, and temperatures on specific films until you find what treatment produces the greatest



Both of these shots of the southern Milky Way are copies of simultaneous 15-minute exposures taken on Ektachrome 400 with identical cameras. The film used for the right-hand photo was hypersensitized in forming gas. Photos by the author.

improvement for each before chemical fogging limits your speed gains. In general, fine grain films will require longer times.

A Comparison Test

As a test, we used matching cameras and 50 mm lenses at f/5.6 to take six exposures in succession of the southern Milky Way from 9100-foot Onyx Peak in the San Bernardino Mountains of southern California. Three days previously, we cut a 20-exposure roll of Ektachrome 400 in half and loaded the front piece on a spare cassette. One cassette was kept in a freezer, while the other was hypersensitized in a mixture of 92% nitrogen/8% hydrogen forming gas for three days at 30° C and 15 P.S.I.

The night was clear and fairly dark. With two people working the twin cameras mounted piggyback on a 12-inch f/5 fork-mounted Newtonian, we made a series of carefully timed exposures in the course of a little over one hour. The exposures were 1, 2, 4, 8, 15, and 30 minutes.

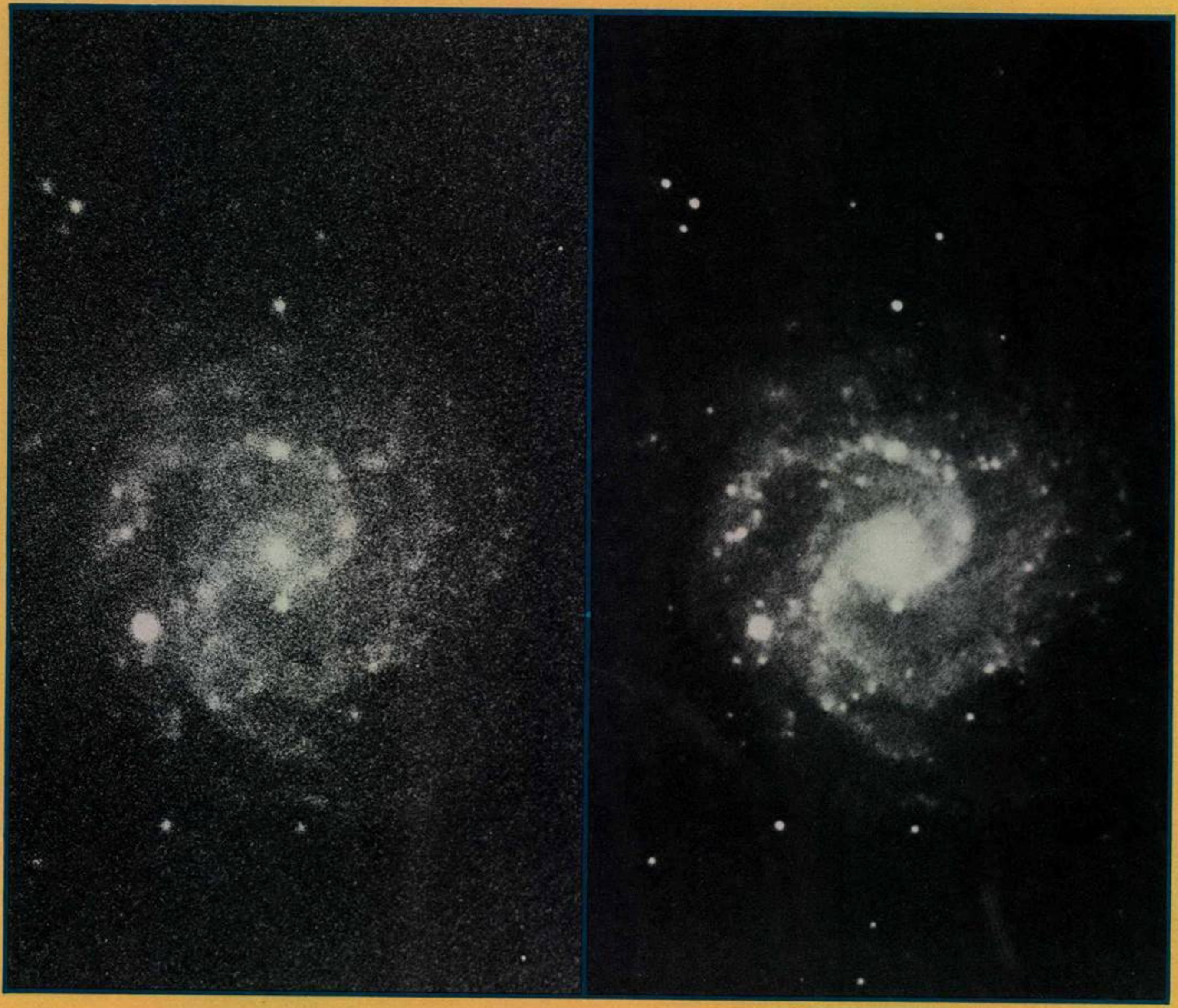
The next day we developed the film normally and made preparations for copying with Ektachrome 64 to help in evaluation. Before the film was even dry, the results were startling. On the sensitized film, the Sagittarius star cloud began to appear on the four minute exposure. But on the normal film it didn't show up until the 15 minute shot. On the 15 and 30 minute sensitized frames, star clouds and dust lanes were fully exposed, while the 30 minute normal exposure recorded only the bright Sagittarius star cloud. As an added bonus, both 15-minute shots happened to record a meteor, which produced a brighter and longer streak on the sensitized frame. And the sensitized film recorded equally faint stars in a fourth the time.

We have not yet mentioned the most spectacular advantage: With hypersensitized film, color balance is much better and copies and prints are more realistic. The brilliant but unreal red of most films is gone from prints made with hypersensitized Ektachrome 400. Instead, a more moderate red or peach color appears, and the blues may be the best since the loss of the now defunct GAF films.

The typical sky background for Ektachrome 400 is greenish (the true color of most night skies), but you can easily turn this into a more esthetically acceptable dark blue or black by copying with a #81 blue photoflood on Ektachrome 64.

Ektachrome 200 gives a reddish-brown sky with less detail, and therefore has no advantage over the larger-grained E-400.

The rather new Fuji 400 color slide film, though, is a useful alternative to Ektachrome 400 (see Astronomy Reviews, March 1981). For us, chemical fogging occurs with Fuji-400 after baking for four days at 30° C and 18



Above left is a photograph of NGC-3814 on 103a-O plate. At right is the same object, photographed on hypersensitized 2415 Tech Pan. Both 16-inch photos courtesy of Edgar Everhart and the Dick Mountain Field Station of Chamberlain Observatory, University of Denver.

P.S.I. We've found that 3.5 days at 30° C and 15 P.S.I. is a good compromise between speed and chemical fogging.

Both Fuji and Ektachrome slide films have appreciable grain, of course, but the advantage gained lies in their considerable speed.

There is less contrast with the hypersensitized film. The positives are thinner and exhibit more subtle tonal shades. This makes them more attractive and easier to copy and print than the normal 400.

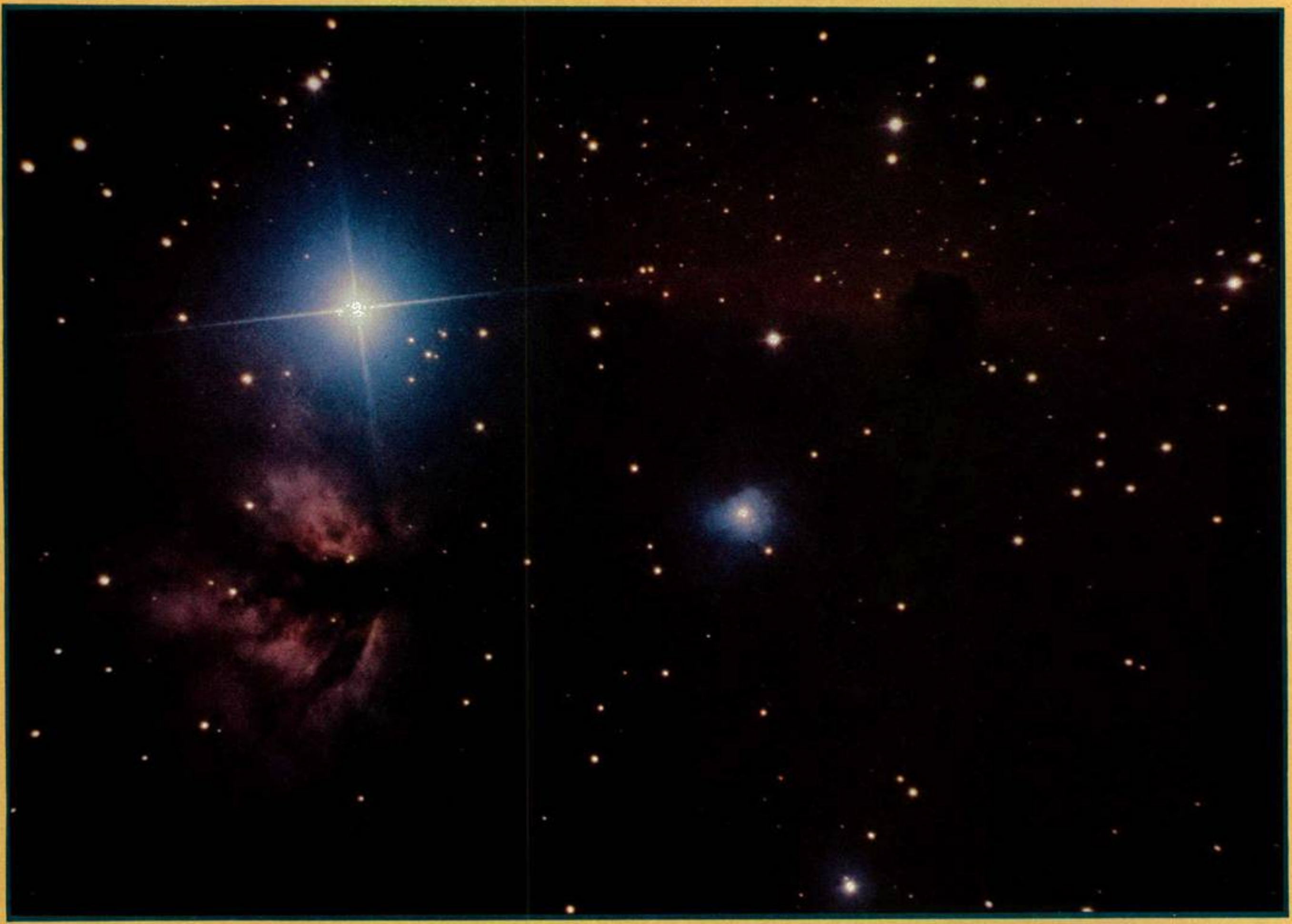
If you have been working with black and white spectroscopic films, you may not be happy with the larger star images and loss of some detail in color films. However, it seems that Kodak Technical Pan Film (type 2415) can rival the spectroscopic films at a tiny fraction of the cost. "Hypered" 2415 Tech Pan has another major advantage over spectroscopic films: it is exceptionally fine-grained. (See "Using SO-115 Film," ASTRONOMY, April 1980. SO-115 is the old name for 2415 Tech Pan.)

Hypersensitizing 2415 film is easy — and the treated film keeps much longer than color films. The fine grain of 2415 makes it especially suitable for astrophotography, and the hypersensitization process considerably reduces the exposure time necessary. 2415 is treated in the same way as Ektachrome 400 — after loading the cassette into the chamber, evacuate the air and introduce forming gas to a pressure of 15-18 P.S.I. Then hold it at a temperature of 30° C for five to six days. The film can also be hypered at a higher temperature for a shorter length of time. The gain in speed — 10 to 30 times — is nothing short of dramatic!

Disadvantages

There is one disadvantage in Ektachrome hypersensitization: deterioration of speed gain after the film is removed from the forming gas. Speed loss occurs even if the sensitized film is stored in a freezer. For this reason, wait to sensitize the film until just before use and then develop it as soon as possible (although a roll of film used on two successive nights showed no adverse effects). It would probably be wise to discard sensitized film which could not be used within a few days. Black and white sensitized films, however, can be stored for several months in a freezer without significant speed loss.

To test the deterioration of speed in sensitized film, we conducted another experiment — this time with a five week separation. The primary object was the Trifid Nebula (M-20), chosen for its combination of blues and reds. The film (E-400) was split and both cassettes went into the chamber for four days at 24° C and 15 P.S.I. Upon removal, one cassette was placed in a freezer in an air-tight container, and the other loaded in a camera. We then



Using a 12½-inch f/5 fork-mounted Newtonian, the author took this photograph of the Horsehead Nebula in Orion with Fuji 400 film and a 26-minute exposure. The film had been hypersensitized in forming gas for 76 hours. The final image as seen above is a 4-second copy on Ektachrome 64.

took four 10-minute prime focus exposures of several popular objects, including the Trifid Nebula. This was from Angeles Oaks, California, with the 12-inch Newtonian previously mentioned.

Five weeks later, at the same site, we exposed the other roll to the Trifid for 10 and 20 minutes. Examination of the films and subsequent copies revealed that the film lost 50% of its speed gain while it sat in the freezer. In other words, it would have taken about 15 minutes to duplicate the results of the original 10-minute exposure.

Sky fog is, of course, the limiting factor for all astrophotographs. And hypersensitized film is faster in reaching this limit — but, as we pointed out, it gives you better pictures, too.

Will forming gas hypersensitization of film eventually replace the cold camera dry ice system? It might — mainly because a standard SLR camera can use hypersensitized film. But our initial comparison tests between the cold camera process and hypered Ektachrome 400 show that while the speed of hypered film *approaches* that of the cold camera, it fails to *equal* it. Still, "hypering" is easier. For example, on the two occasions when the tests were made, the cold camera shots were out of focus! In any case, one thing is sure: there will be a great deal of discussion over the next few years comparing the advantages and disadvantages of both systems....

Next month, in part 2, read about building your own forming gas hypersensitizing unit.

references

Hypersensitization is a relatively new process and few references exist, but the following articles may be helpful:

R.L. Scott, Alex G. Smith, & R.J. Leacock: "The Use of Forming Gas in Hypersensitizing Kodak Spectroscopic Plates," *AAS* (American Astronomical Society) *Photo-Bulletin*, Issue No. 15, 2 (1977), page 12.

N.V. Vidal: "Hypersensitization of Kodak IIIa-J and 103a-D Emulsions with Forming Gas," *AAS Photo-Bulletin*, Issue No. 21, 2 (1979), page 3.

Alex G. Smith & Hans W. Schrader: "Balanced Hypersensitization of a Fast Reversal Color Film," *AAS Photo-Bulletin*, Issue No. 21, 2 (1979), page 9.

Robert Provin and Brad Wallis: "Hydrogen Hypering — Hot Stuff or Hot Air?", *Astrophoto II Proceedings* (1977).

Issue No. 24, 2 (1980) of the *AAS Photo-Bulletin* includes the following relevant articles:

Edgar Everhart: "Hypersensitization and Astronomical Use of Kodak Technical Pan Film 2415."

Patrick E. Walker: "Hypersensitization of Kodak Technical Pan Film 2415 by Bathing in Silver Nitrate Solution."

Jack B. Marling: "Gas Hypersensitization of Kodak Technical Pan Film 2415."

Alex G. Smith: "Measurement of Absolute Photographic Sensitivity."

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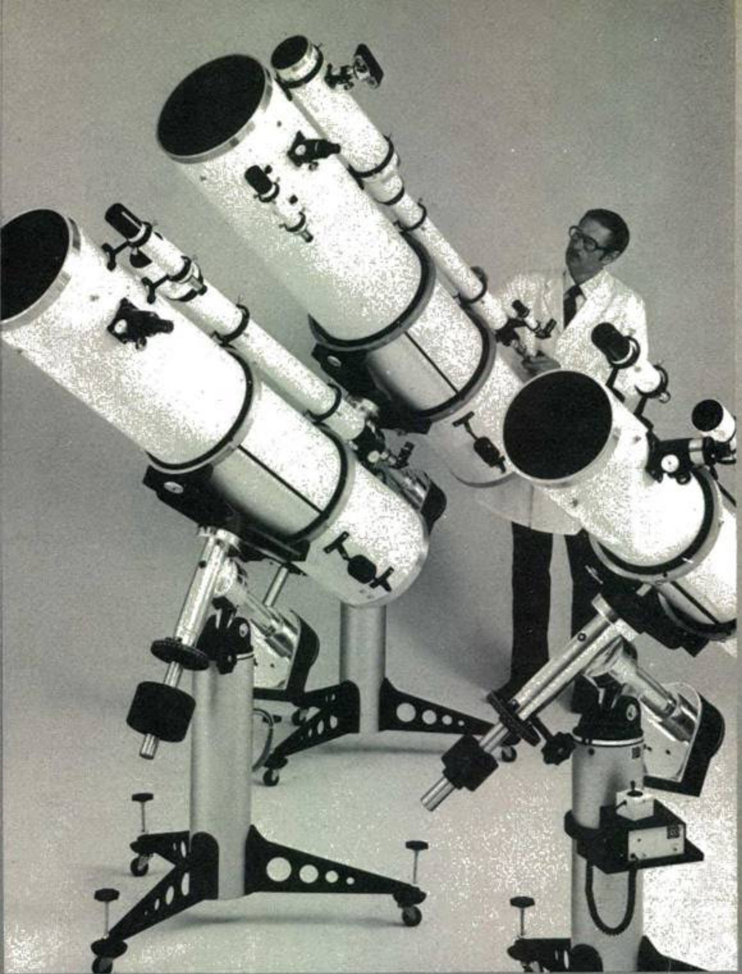
Designed by Meade engineers and in continuous production at our Costa Mesa facility, these telescopes possess capabilities generally obtainable only at much higher prices — and they are the only telescopes available which use exclusively the quality Meade components known throughout the astronomical world.



Meade Research Series (above)—The accepted standard of the American telescope industry for the advanced amateur.

COMPLETE RESEARCH SERIES REFLECTING TELESCOPES

Model 880: 8" f/6 with Motor Drive	**$ 995**
Model 1060: 10" f/6 with Motor Drive	**1285**
Model 1266: 12½" f/6 with Motor Drive	**1675**

Packing charges: 8" — $50; 10" — $60; 12½" — $75. All prices F.O.B. Costa Mesa, Calif.

Model 826 8" f/6
with Motor Drive
$489.95
Packing Charge: $25.00

Shown with optional Manual Declination and R.A. Controls, 2" Photo-Guide Telescope, VariGuide R.A. Drive Corrector, Accessory Shelf.

PRICE INCREASE ANNOUNCEMENT!

Prices of Meade astronomical telescopes will increase by **10%** to **15%** on **June 1, 1981. Orders** received by May 31, 1981, will be shipped at the current prices shown in this ad.

COMPLETE REFLECTING TELESCOPES

All Meade reflecting telescopes now include high-transmission Multi-Coated eyepieces at no additional cost!

Model 591: 6" f/8 with Motor Drive	**$319.50**
Model 628: 6" f/8 with Motor Drive	**379.95**
Model 618: 6" f/8 without Motor Drive	**339.95**
Model 645: 6" f/5 with Motor Drive	**389.95**
Model 635: 6" f/5 without Motor Drive	**349.95**
Model 826: 8" f/6 with Motor Drive	**489.95**
Model 816: 8" f/6 without Motor Drive	**429.95**
Model 856: 8" f/6 with Motor Drive, 2" Photo-Guide Telescope, and VariGuide Dual-Axis Control System	**770.00**
Manual Declination control #55 for Models 628-856	**37.50**
Manual R.A. Override Control #57 for Models 628-856	**15.00**

Packing charges: 6"–$15; 8"–$25 – All Prices F.O.B. Costa Mesa, Calif.

COMPLETE EQUATORIAL MOUNTS. The same precision mounts used on Meade 600- and 800-Series reflecting telescopes. Each mount includes: ball bearing equatorial head, cradle rings, setting circles on both axes, pier, and tripod legs. Manual R.A. Override Control #57 is available for motor drive models.

Model 651: 6" Equatorial Mount without Motor Drive	**$140.00**
Model 653: 6" Equatorial Mount with Motor Drive	**195.00**
Model 851: 8" Equatorial Mount without Motor Drive	**165.00**
Model 853: 8" Equatorial Mount with Motor Drive	**225.00**
Manual Declination Control #55 for Models 651-853	**37.50**
Manual R.A. Override Control #57 for Models 653, 853	**15.00**

Packing charge on all mounts: $10 – All Prices F.O.B. Costa Mesa, Calif.

Meade

Research level telescope parts and accessories from America's No. 1 supplier to the serious amateur

RACK-AND-PINION FOCUSERS—Precision metal construction. All 3 models include helical-cut rack and variable-tension adjustment for ultra-smooth focusing without backlash. Universal bases fit all tube sizes. Standard 1¼" eyepiece holders. **Each focuser is guaranteed to be the finest obtainable in its class:**

1—MODEL 67—Strong, lightweight design for 4" to 10" telescopes. 2-3/16" travel. An excellent value. **$21.75 ppd.**

2—MODEL 640—A heavy-duty deluxe focuser for 6" to 16" telescopes. Full 3" travel for both visual and photographic applications. **$35.95 ppd.**

3—MODEL 680—Our finest focuser. Accepts both 1¼" and 2" eyepieces. Full 3" travel for photo or visual observing with 6" to 16" telescopes. **$42.95 ppd.**

4—NEBULAR FILTER—This revolutionary 3-channel filter effectively blocks sodium and mercury emissions from city lights as well as natural airglow, while transmitting 90% of critical visual nebular emissions. Dramatically improves telescope performance visually and photographically. Hermetically sealed, anti-reflection coated. 23mm clear aperture. Threads directly into all Meade 1¼" O.D. eyepieces. **$59.95 ppd.**

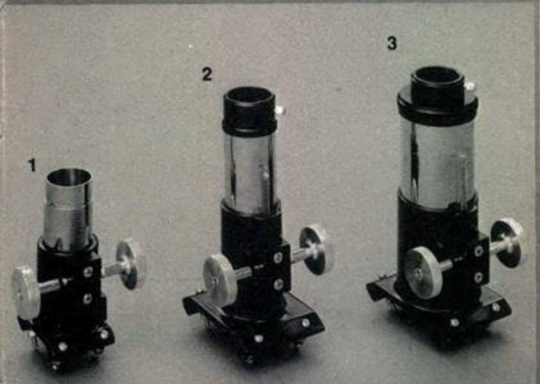
5—PHOTO-VISUAL COLOR FILTERS—Top quality optical glass, dyed-in-the-mass, with excellent spectral homogeneity. Mounted in machined metal cells which thread directly into all our 1¼" "Series 1", "Series 2", and "Research-Grade" eyepieces. Filters may be piggybacked. Listed by Wratten No. and color: **#8 Light Yellow—#11 Yellow-Green—#12 Yellow—#21 Orange—#23A Light Red—#25A Red—#47 Violet—#58 Green—#80A Blue—Polarizer (30% transmission).** Each filter: **$7.95 ppd.** Set of any 6: **$44.50 ppd.**—Full set of 10: **$73.50 ppd.**

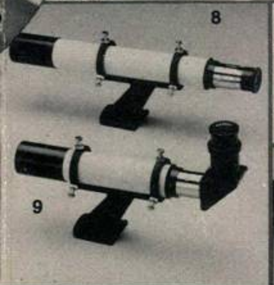
6—VARIPAK DRIVE CORRECTOR—Model 43—A quality electronic guiding unit with supercompact (2" × 3" × 4") design. Fast-slow pushbuttons mounted on the power pack. Variable control for lunar, planetary, sidereal rates. Operates from 12 volts D.C., plugs into standard auto cigarette lighter. The 12-watt output is sufficient for most telescopes to 14" aperture. **$49.95 ppd.**

7—VARIGUIDE DRIVE CORRECTOR—Model 41—The finest R.A. drive corrector available. Includes aircraft-type joystick controller for continuously variable correction rates, not just "ON-OFF". May be used with any motor-drive-equipped telescope rated up to 12 watts, including most commercial telescopes to 14" aperture. Operates from 12 volts D.C. or 115 volts A.C./60Hz. Control box includes variable center-frequency settings for lunar, planetary, sidereal rates. **$119.95 ppd.**

8—6×30mm VIEWFINDER—Fine wide-field finder, the same unit supplied as standard equipment on Meade 6" and 8" reflecting telescopes. Actual field-of-view in excess of 4°. Includes coated, achromatic objective lens and crosshair eyepiece. Precise push-pull focusing. Thousands now in use. 2-ring bracket, with collimation screws and lock-nuts, included. Bracket fits all tubes 6" to 12½". **$22.95 ppd.**

9—6×30mm RIGHT-ANGLE VIEWFINDER—As in (8), but with diagonal prism for convenient right-angle observations. Prism may be rotated through 360° for maximum viewing comfort. 2-ring bracket included. **$27.95 ppd.**





Multi-Coated Series 2 and Research-Grade Eyepieces

Manufactured to entirely new Meade designs, these Series 2 eyepieces are a significant advance in eyepiece technology. Utilizing modern high-density optical glasses, each eyepiece has been computer optimized to yield the highest level of optical performance obtainable within its design class. **Air-to-glass surfaces on all Series 2 and Research-Grade eyepieces are Multi-Coated for maximum light transmission and image contrast.** All 1¼" barrels are threaded for Meade filters.

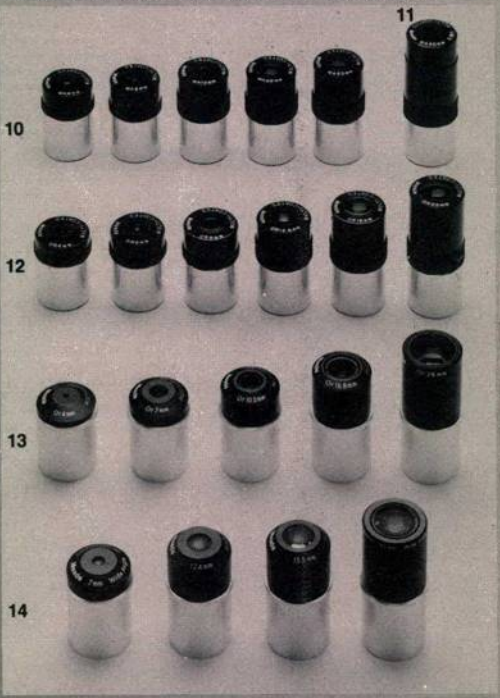
10—SERIES 2 MODIFIED ACHROMATIC EYEPIECES (1¼"O.D.; MULTI-COATED)—Fine 3-element systems, precisely corrected for chromatic and spherical aberrations. Guaranteed to be the finest eyepieces obtainable in their price class.
FOCAL LENGTHS: MA 6, 9, 12, 25mm and 40mm Wide-Field .... each $19.50 ppd.

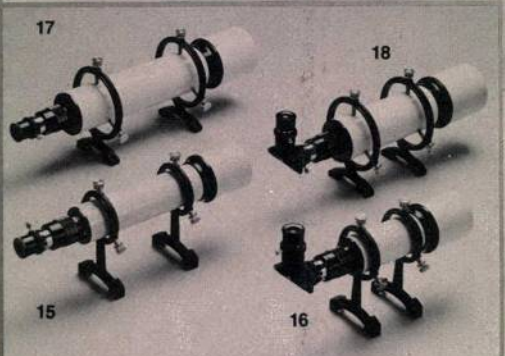
11—MODIFIED ACHROMATIC 40mm EXTRA-WIDE-FIELD EYEPIECE (1¼" O.D.; MULTI-COATED)—Yields widest field obtainable in 1¼" O.D. Enlarged field lens and special field-flattening optics with long eye relief. **$27.75 ppd.**

12—SERIES 2 ORTHOSCOPIC EYEPIECES (1¼" or .965" O.D.; MULTI-COATED; PARFOCAL)—The excellent 4-element high resolution optics of these oculars are all that the majority of serious amateurs will ever require. Razor sharp 45° fields. Both the 1¼" and .965" O.D. sets are accurately parfocalized.
FOCAL LENGTHS: OR 4, 6, 9, 12.5, 18, and 25mm...each $27.95 ppd.

13—RESEARCH-GRADE ORTHOSCOPIC EYEPIECES (1¼" O.D.; MULTI-COATED; PARFOCAL)—The largest selling premium-quality eyepieces in the world, universally acclaimed to be the finest eyepieces obtainable. These 4-element systems are unsurpassed in color correction, resolution, and flatness of field. 45° field. Accurately parfocalized.
FOCAL LENGTHS: OR 4, 7, 10.5, 16.8, 28mm...each $39.50 ppd.

14—RESEARCH-GRADE ERFLE EYEPIECES (1¼"O.D.; MULTI-COATED; PARFOCAL)—For breathtaking wide-angle observations. 65° fields, parfocalized with our Research-Grade Orthoscopics.
FOCAL LENGTHS: ER 7, 12.4, 15.5, 20mm...each $42.50 ppd.





VIEWFINDERS—With helical focusers for ultraprecise control of image sharpness. Coated, achromatic objectives of new Meade design yield fully corrected images throughout the field. Actual field on 50mm models: 4¼°; on 60mm models: 3½°. Crosshair eyepiece, dewcap, dustcap included. The 60mm models are particularly recommended for telescopes 8" and larger, where the large finder aperture is a tremendous aid in the location of faint objects.

15—8×50mm—$39.50 ppd. Brackets: **$7.95/pr. ppd.**

16—8×50mm RIGHT-ANGLE—$46.50 ppd. Brackets: **$7.95/pr. ppd.**

17—GIANT 9×60mm—$62.50 ppd. Brackets: **$12.75/pr. ppd.**

18—GIANT 9×60mm RIGHT ANGLE—$69.50 ppd. Brackets: **$12.75/pr.**

19—RESEARCH-GRADE ERFLE 32mm EYEPIECE (2"O.D.; MULTI-COATED)—Wide-angle, fully-corrected 65° field. The finest eyepiece obtainable in 2" barrel. **$84.95 ppd.** Adapter Barrel for 1¼"O.D. ...**$7.50 ppd.**

20—DELUXE CAMERA ADAPTERS—Adapt your camera to telescope focuser instantly. Individually machined from solid bar aluminum and brass. All units permit both eyepiece-projection and first (prime) focus photography. Specify either 1¼" or .965" focuser. All 1¼" units are threaded for our filters. **Pentax, Yashica, Mamiya...$18.95 ppd.—Nikon, Canon, Minolta, Pentax K, Exakta, Konica, Olympus OM-1, OM-2...$26.75 ppd.**

21—2X TELENEGATIVE AMPLIFIER (1¼" O.D.; MULTI-COATED)—Model 122: Warranted without qualification to be the world's finest Barlow lens. Full 26mm clear aperture, Multi-Coated, with virtually flawless optical corrections at all photo-visual wavelengths. Produces optimum performance on telescopes of any focal ratio...**$29.50 ppd.** **Model 131:** Per Model 122, but for .965" focusers; 18mm clear aperture. Multi-Coated...**$24.50 ppd.**

22—2X-3X VARIABLE TELENEGATIVE AMPLIFIER (1¼" O.D.; MULTI-COATED)—Model 127: Manufactured to the same research standards as the Model 122 above, but mounted in a precisely machined sliding cell, to permit variable power settings between 2X and 3X. Engraved scale indicates power. Multi-Coated...**$36.50 ppd.**

23, 24—ACCESSORY CASES—Rugged polyethylene, for dust-free protection of eyepieces, filters, Barlows, etc. Die-cut foam lining. **Model 51: 7" × 8½"... $8.95 ppd.—Model 54: 8" × 12"...$12.95 ppd.**

25—ILLUMINATED RETICLE GUIDING EYEPIECE (1¼" or .965" O.D.)—New phosphorescent etched double-line reticle permits line illumination from dim to extremely bright. Remote brightness control and 6 ft. cable. Modified Achromatic 12mm optical system. Precisely focusable reticle. Complete...**$49.95 ppd.**
Micrometer Reticle. Full-field scale for accurate measurements of double star separations, planetary angular diameters, etc. Interchanges with standard 4-line reticle...**$14.95 ppd.**

26—ERECTING PRISMS—Fully coated Porro prisms, for terrestrial observations with astronomical telescopes. **1¼" O.D. ...$32.95 ppd.**
.965" O.D. ...$24.95 ppd.

27—DIAGONAL PRISMS—Quality right angle prisms, fully coated. **1¼" O.D. ...$19.95 ppd.—.965" O.D. ...$14.95 ppd.**

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SIBERIAN ECLIPSE EXPEDITION JULY 31, 1981

JOIN US ON ANOTHER ASTRONOMICAL ADVENTURE

This one to the Soviet Union, to view an eclipse from Bratsk, Siberia!

Sun: at 44° during totality Duration: 1:48, approximately

July 24–August 7, 1981

This Deluxe 15-Day Russia-Eclipse-Finland Tour encompasses 9 days in the Soviet Union for sightseeing (specific itinerary below) and the eclipse, and 5 days in Finland.

Flights to the Soviet Union and the return to the U.S. are via Finnair. Transportation to and from the eclipse sight is via chartered Aeroflot jets which are for the exclusive use of ***Star & Sky Expeditions.***

Highlights of the trip and the day-by-day itinerary are as follows:

July 24th

Day 1: Depart New York (or any other gateway city) for Helsinki.

Day 2: Arrive **HELSINKI** and remain overnight.

Day 3: Arrive **MOSCOW** in morning. Visit **MOSCOW PLANETARIUM** and have **MEETINGS WITH SOVIET ASTRONOMERS.** Welcome Cocktail Party and Dinner this evening.

Day 4: In Moscow visit **RED SQUARE, THE KREMLIN, LENIN'S TOMB.** Tickets this evening to the **BOLSHOI BALLET, RUSSIAN CIRCUS,** or **FOLK DANCE** performance.

Day 5: In Moscow visit **MOSCOW UNIVERSITY, STERNBERG ASTRONOMICAL INSTITUTE.** Dinner at the famous Arbat Restaurant.

Day 6: Depart this afternoon for flight across Siberia to Bratsk.

Day 7: **BRATSK** city tour and visit to hydroelectric installation.

Day 8: **ECLIPSE DAY** in Bratsk. Flight departure this afternoon for Leningrad.

Day 9: **LENINGRAD.** Visit to **ST. ISAAC'S CATHEDRAL, THE WINTER PALACE, THE HERMITAGE.**

Day 10: **LENINGRAD / PETRODVORETS. HYDROFOIL CRUISE TO GULF OF FINLAND AND THE SUMMER RESORT OF PETER THE GREAT.**

Day 11: Leningrad. Visit **PULKOVO OBSERVATORY** this morning, depart late afternoon for Helsinki.

Day 12: **HAMEENLINA, FINLAND. IITTALA GLASS FACTORY TOUR** plus **LAUNCH TRIP TO VISAVOURI.**

Day 13: Hameenlina, Finland. Day at leisure to enjoy the amenities of this popular Finnish resort hotel with pools, horseback riding, golf, biking, hiking, and much more. Gala Awards Dinner with a viewing of the eclipse slides that we will have had developed.

Day 14: **HELSINKI CITY TOUR AND BOAT TRIP TO SEAURASAARI** where ancient Finnish villages have been restored and we are greeted by Finnish Folk Dancers. **MEETING THIS EVENING WITH FINNISH ASTRONOMERS.**

Day 15: Depart Helsinki for the U.S.

All in all a deluxe tour that includes most meals, accommodations at the best hotels in the Soviet Union and Finland, tour guides, translators, motor coach transfers, tips, and much, much more. Write today for further details. Space is limited and will be on a first-come-first serve basis. Price is $2950 from New York (slightly higher from the West Coast). For your brochure and reservation form write to:

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44 Church Lane, Westport, CT 06880

FINNAIR TOURS

How to Build a
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TELESCOPE
Reprints from TELESCOPE MAKING magazine

Your Guide to Assembling the Largest Aperture, Lowest Cost, Most Convenient Telescope You Can Build

Would you like to build your own 10″ telescope? or a 12″, 16″ or even 20″? Well, you can — and for a lot less time and money than you ever thought possible. The secret is the Dobsonian — elegant in design but simple to build. Our 36-page booklet gives you practical, clearly written, easy-to-follow instructions, helpful diagrams, and plenty of informative photographs. To order use form between pages 60-61 or send $3.95 to:

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all the angles on magnification

What power should I use with my new scope to look at Jupiter?

Why not just use a magnification that gives a satisfying view?

But isn't there some formula — or maybe an equation — for the best view through a telescope?

Not really. After all, the best view is pretty subjective. Why don't you try some different magnifications and see for yourself.

There's so much math to this astronomy thing; I thought looking didn't count anymore.... I'm going to start at 50x.

Well? How does Jupiter look?

I'm getting an overall view of Jupiter and its moons. Jupiter looks like a small whitish ball and I can see all four bright moons with no trouble. If I look more closely, yes, now I guess I see a few belts running along the same line as the moons. The belts are really pale, though.

estimating sky angles

Small Angles	
Diameter of the Full Moon	½°
Between the Pointers in the Dipper	5°
Castor to Pollux	5°
Beta to Gamma Aquilae	5°
Medium Angles	
Alpha Pegasi to Beta Pegasi	12°
Betelgeuse to Rigel	18°
Polaris to Dubhe	28°
Tip of the Dipper's Handle to Arcturus	30°
The Length of Cygnus: Deneb to Albireo	22°
The Length of Leo: Regulus to Denebola	24°
Large Angles	
Betelgeuse to Polaris	82°
Aldebaran to Polaris	73°
Markab (Alpha Pegasi) to Polaris	75°
Regulus to Polaris	77°
Arcturus to Polaris	71°
Altair to Polaris	81°

Remember that Jupiter's belts really are pretty pale. Have all those Voyager pictures spoiled your taste for the real thing?

Oh no, not at all! Now here goes 100x. What does "x" mean, by the way? Does it stand for something?

It's the multiplication symbol "times" and tells you how many times bigger a telescope makes things look.

I see. But times *what*?

Answer this first: How big does Jupiter look to you now?

At this power, Jupiter looks about the size of a dime held at arm's length. It's rather pretty, too. I can see the belts a lot better now, even though they're awfully weak. I see some pinky colors and shades of brown in the darker stripes. I'll move over and you can take a look.

Thanks. Now, what I'm looking at here is 100 times bigger than something, right?

Right. But it's not 100 times bigger than a dime at arm's length, is it? That doesn't mean anything.

I'll give you a hint. "A dime at arm's length" is one way to describe an angle....

Angle? With degrees and a protractor? I remember that stuff from school. That's trigonometry: Ugh!

Angles aren't so bad. And you'd better get used to them, because angles are what your telescope magnifies.

I don't have any love of angles at all. They're just lines to me.

You can learn to estimate angles by eye, you know, with a little practice.

Oh really?

Sure. The Full Moon is half a degree across. The pointer stars in the Big Dipper are 5° apart. Orion is 16° tall. The inner pointer star is 27° from Polaris. And, the angle from straight overhead to the horizon is 90°.

That makes angles seem a bit more real. How do I estimate now?

You make a comparison. Look from one to the other. Ask yourself, "If this one is 5°, then what's that one?"

It sounds crazy, but I'm game. First, though, I'm putting some more power on Jupiter. This is 120x.

Would you like to estimate the angle Jupiter fills in the eyepiece? Go ahead — look.

Hmmmm. Hmmmm. I'd say about twice the diameter of a Full Moon. No, make that three times. It's certainly less than four times as big.

Okay. So that's a degree and a half. Roughly, of course.

Now what?

Well, if you divide 1.5° by 120, you'll get the real "angular diameter" of Jupiter in the sky.

It's a lot less than a degree. It's, um, 1/80th of a degree, I think. No wonder Jupiter looks like a star in the sky.

Wouldn't you hate to measure that angle with a protractor?

It'd have to be an awfully thin sliver. But a degree and a half looks pretty large in your telescope, doesn't it?

I'm going to put in another eyepiece. This one's an 8-millimeter eyepiece. Since my scope has a focal length of 1600 millimeters, it'll give me 200x.

You've learned that pretty well!

Oh sure. I use it every time I use the telescope. You just divide the focal length of the telescope by the focal length of the eyepiece to get the magnification.

But I thought you were the one who's afraid of equations.

Oh, that's no equation! That's easy enough to do in my head. Anyway here's Jupiter again...it looks bigger, too.

Now it'll be roughly 2½° across — a quarter at arm's length.

It doesn't look as sharp as it did before, but I can see more detail on

Jupiter itself — little wiggles and swirls in the belts. The longer I look, and the more my eyes get used to seeing this stuff, the better I see it.

Aha. You're getting an educated eye.

Look at the moons — they're wiggling and changing shape! Here — take a look.

Yes — that's called "seeing." At 200x you can expect seeing effects most of the time.

Well, in looking through 150 miles of air, I'd expect a few problems.

Air currents bend the light beam around — so it looks as if the object itself is moving or changing shape.

And that limits what I can see, doesn't it?

Yes — it's one of the limits. "Seeing" is usually about one second of arc at a good site, and worse in most places.

What's the other problem?

Light itself. A telescope forms an image that's not a perfect point of light, but is enlarged by the diffraction of light waves. The spot is called the Airy disk. For this telescope, with a ten inch mirror, the Airy disk is a bit over one second of arc across.

Wa-a-ait a minute; you've lost me. I've read about diffraction before — but how big is a second of arc?

You know what a degree is, don't you? It's 1/360th of a full circle. When it comes to measuring small angles, fractions of a degree are too clumsy, so degrees are divided into minutes and minutes into seconds. There are 60 minutes in a degree and 60 seconds in a minute.

So there are 60 times 60, or 3600, seconds in a degree? That's a lot of seconds — it makes the Moon about 1800 seconds of arc across.

There are 1,296,000 seconds of arc in a full circle of 360°.

Is Jupiter measured in seconds of arc?

Usually it is.

I'll just get out my trusty calculator then and convert it from 1/80th of a degree. 3, 6, 0, 0, divide, 8, 0, equals 45. So Jupiter is about 45 seconds of arc across.

Right. Remember now, the size of average good seeing and also the size of the Airy disk with this telescope is about 1 second of arc.

So Jupiter is only 45 of these Airy disks across?

Yes, and remember, even with big telescopes, seeing limits the resolution to about a second of arc.

So that's why Voyager's pictures showed so much more than Earth-based telescopes — even the 200-inch!

Sure. And now for the $64,000 question: How big does 200x make 1 second of arc look to you?

That's easy: 200 seconds of arc.

Good enough. Most people with good eyes can just distinguish a disk 120 seconds of arc across.

So Jupiter looks a little fuzzy because my eye can resolve the fuzziness in the image?

You can see more than you could with a lower power. At 200x, you can make out all the detail there is to see. Under good conditions, more magnification is helpful.

Well, I'm going to put on my 4-millimeter eyepiece — that's 400x. We'll try some more power.

Well — how does it look now?

It's big. And it's fuzzy. I don't think I can see as much detail as I could at 200x because the image is getting dim.

That's because you're taking the same amount of Jupiter light and spreading it out over a bigger and bigger angle...

...And I can see the fuzziness *too* easily now. Oh wow, look at those moons boil! They look like they're under water. No wonder astronomers hate the atmosphere.

Well, we do need it to breathe, you know.

I'll ignore that. Is 400x "empty magnification"? This view is for the birds!

Well, you are magnifying everything 400 times. That's a lot of power — and it gives you a pretty small field, too.

Do you know how I can figure out what the field of view is?

Which — the apparent field you see in the eyepiece, or the real field the telescope sees in the sky?

The real field.

Well, start Jupiter at one side of the field and time how long it takes to drift all the way across.

I'll count it off in lollipop seconds — that'll be accurate enough. I'll set Jupiter just entering the field. One lollipop, two lollipops, three lollipops......twenty-nine lollipops, thirty lollipops. There. It's gone out. It took about thirty seconds to cross the field. What's next?

The rotation of the Earth makes objects near the celestial equator move 360° in 24 hours, or 1° in four minutes. Since 30 seconds is ⅛ of four minutes, then your true field of view is ⅛ of a degree, or 7½ minutes of arc.

That's a quarter the diameter of the Full Moon, isn't it?

Right.

So when I look, I see that little 7½ minutes of arc blown up to an angle 400 times larger when I look in the telescope!

Right: 7½ minutes of arc times 400 is 50 degrees.

Fifty degrees is the apparent field, right? Is that what I see when I look into the eyepiece?

Right.

So if I compare this field to the distance from the Dipper's pointer stars to Polaris, it'll be a bit under twice as wide to my eyes. That's pretty big.

Any field over 40° feels big to me. But smaller fields are rather claustrophobic.

That describes the old brass eyepiece I have to a "tee." It must date back to 1901.

Eyepiece design has come a long way since then. Fields of 60° aren't uncommon — and they're wonderful to look through. You feel like you're out there floating in space.

I like a nice sharp edge of the field. I can't explain — I just like it that way.

It's neat and tidy — as if you were looking out a window.

And, I've noticed, for observing planets or double stars, it doesn't really matter how wide the field is. I usually put what I'm observing in the center anyway.

Except tonight. The clock drive isn't running.

That's because this telescope has no clock drive! Anyway, I was planning to observe galaxies in Leo at low power.

All right, but before you do that, let's take a look at Saturn.

I'll switch back to low power for finding it. There, it's in the finder. It ought to be in the main scope, too. Oh yes, looks very nice. I can see Titan and maybe another satellite. But tell me now — this business about "power per inch," how does that figure into all of this magnification stuff?

You can answer that yourself, if you think about it a bit. First, divide the magnification you have now by the aperture of the telescope.

Well, it's a 10-inch scope with a 64-

magnification recommendations

4 to 6 per inch	rich-field viewing, star fields, comet seeking, observing deep-sky objects
6 to 12 per inch	general viewing for all objects
12 per inch	resolution of the eye matches the telescope resolution, lowest power to see all image detail
12 to 25 per inch	normal lunar and planetary observing detail in bright deep-sky objects
25 to 50 per inch	lunar, planetary, and double star observing under excellent conditions

inch focal length, so this 32-mm eyepiece gives me 50x. That must make it 5 times per inch.

Yes. You see, magnification per inch of aperture is just a general guideline about how much magnification works well on a telescope.

Does it work for any size telescope?

Yes. The lowest you can use is about 3.5x per inch. 4x to 6x per inch means low-power observing — good for deep-sky objects and finding things as you just did.

This power per inch rule means that big telescopes have a higher magnification when they're at their lowest power, doesn't it?

Certainly. That's why big telescopes show you more.

I like low magnification because the field is so wide. There are so many stars. And it saves me searching for dim objects. They're almost always in the field even if I don't know their position too well.

That's the advantage of an RFT. You get a "rich field."

Well, I'm going to put in the 16-millimeter eyepiece now. That's 100x — 10x per inch.

Good for general observing. The image looks sharp, and the real field of view is large.

I remember last winter that the Orion Nebula was fabulous at this power.

Did you see any color in it?

No, it looked blue-green or maybe grey. I've been wondering what's wrong. I couldn't see color at any magnification I tried, but all the pictures of it have color.

You won't see color — or at least not the strong colors you see in photographs — with any telescope at any magnification. The nebulae are too dim to stimulate the color receptors in your eyes very much.

Even with a really big telescope under clear mountain skies?

You might see just a hint of color, some ruddy or bluish areas....

But they really are colored aren't they?

Yes, and with a time exposure, color films record that color.

So there's nothing wrong with me or the telescope? What a relief!

Now, back to Saturn....

It looks like a jewel on black velvet. So crisp! And I see Titan and two — maybe three — of its dim moons.

This is the best view to show friends who don't know much about astronomy. Keep the magnification fairly low.

Will it get better at 200x? We'll soon see. Here goes.

At 20x per inch, your eye can resolve all the detail the telescope can deliver.

Yes, it's maybe just a little soft. But I can see a cloud belt on it, and Cassini's Division in the ring, and the shadow of the rings on Saturn. This is a very satisfying view. What a planet!

Let me take a look.

As soon as you're done, I'm going to try 400x.

I'll bet that Saturn looks as fuzzy as Jupiter did at that power.

Well, I'll try it. The Moon seems to take 400x pretty well on some nights. Yuk! — you're right. Saturn's even dimmer than Jupiter was.

Do you have an eyepiece for slightly lower magnification?

Here's the 6-millimeter — you can try it if you want — it'll give about 300x.

Thanks. I must say one thing for this telescope of yours: these formica and teflon bearings work very smoothly. Tracking's no problem even at these high powers.

What I especially like about it is that it doesn't jiggle. If it's jiggly, you can't use high powers at all.

Yes. An unsteady telescope is a lot worse than bad seeing.

You can say that again.

Well — let's find a few galaxies....

Sure. Here's the star map. Let's find M-65 and M-66. Y'know, I've got a question: Since the image gets dimmer as I increase the magnification, why can't I use magnifications lower than 3.5x per inch and make the image brighter? It would really help on these galaxies.

Roger Sliva used "hypered" Fuji 400 film to record the colors of the Orion Nebula.

The exit pupil gets too large for all the light from the eyepiece to enter your eye. You find the exit pupil diameter by dividing the aperture of the telescope by the magnification.

So that's 10 inches, or 250 millimeters, divided by 35. It'll give a 7-millimeter exit pupil. Much bigger than that, and all the light from the telescope couldn't enter your eye.

I'm not losing very much with this 32-millimeter eyepiece, though. It gives a 5-millimeter exit pupil.

For most people, the image with a 7-millimeter exit pupil isn't very sharp. The natural aberrations in the outer parts of the lenses of their eyes give stars little tails or spikes.

So 5 or 6-millimeter exit pupils give a more satisfying view?

Quite often they do.

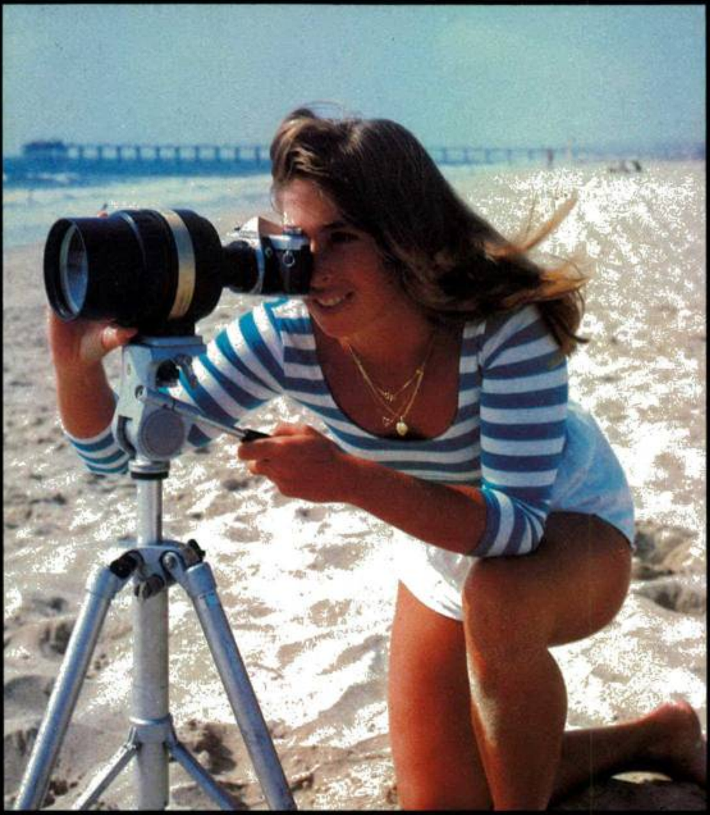
Wow, there are so many compromises! Hey — I just thought of something wild: what's the power per inch for an eye?

The magnification of our eyes is one, and if its aperture is 6 millimeters, or about a quarter inch, the power per inch is 4x. So it really works out.

— *Richard Berry*

Celestron®

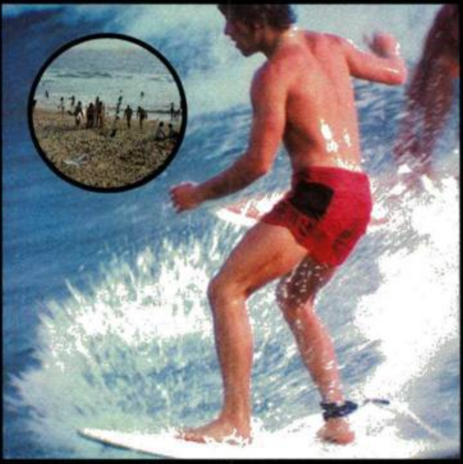
500mm f/5.6 Telephoto Lens



Celestron is proud to announce its newest telephoto lens to our extensive line of American made telephotos and telescopes, the new 500mm f/5.6 telephoto lens. As with every other Celestron, it can be used as a long telephoto lens or converted in seconds to a supercompact spotting scope with optics that allow you to photograph and/or view virtually anything on the ground or in the sky. This telephoto features Maksutov-Cassegrain optics of 90mm aperture with a focal length at f/5.6 to give you razor sharp, bright images.

500mm photo-inset with normal 50mm lens

Vulture at 30 feet



Sports Action-inset 50mm photo

Features of the 500mm F/5.6 Telephoto

- 500mm focal length—long enough for close up shots for sports and action photography but short (and fast) enough to handhold.
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- Tremendous versatility—can be used as a fast telephoto lens and as a visual telescope for viewing terrestrial or astronomical subjects by the simple addition of visual accessories.
- Large 90mm aperture—this large diameter optical system will allow superior angular resolution both photographically and visually.
- Highly portable—the length is only 7.5″ (190mm) and weighs only 2 pounds 14 oz. (1.3 kg).
- Rugged construction—mechanical components made with precision die cast aluminum. Will withstand rough handling.
- Macro capability—the near focus is approximately four feet.
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- High optical quality—diffraction limited. Every optical system is hand figured by a highly skilled optician to achieve sharpest possible images.
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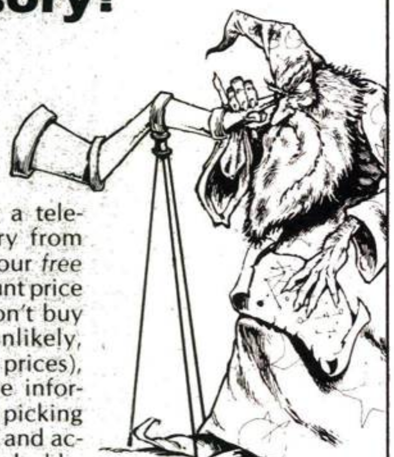

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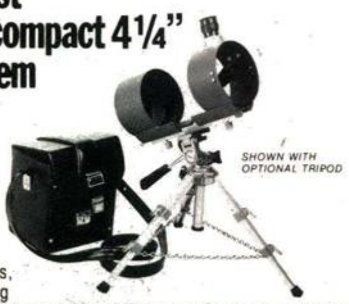

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gazer's
gazette

image orientation

by
Earle Dodds

Most observers know that the woman profiled in the right-hand half of the Moon usually appears upside down and facing to the right when seen through the eyepiece of a telescope. But in some telescopes she is not only upside down but also facing our left!

This problem is easy to deal with, but when you use a star chart to identify configurations you see in the eyepiece, it becomes more vexing. Star charts usually are printed with north at the top, while the small maps and charts of limited sections of the sky which appear in most astronomical periodicals (including ASTRONOMY) are inverted. The accompanying text usually states something like: "south is at top, as in an ordinary inverting telescope." The problem arises when you go out to observe, locate the correct field, look through the eyepiece and — surprise! What you see is nothing like the chart you have in your hand. Have you made some mistake in locating the region? Probably not — with the increasing use of right-angle eyepiece holders on refractors, finders, and catadioptrics, and with three mirror systems such as tri-schiefspieglers and stationary eyepiece Newtonians showing up more and more often, the astronomical telescope isn't always an "ordinary inverting telescope" any more.

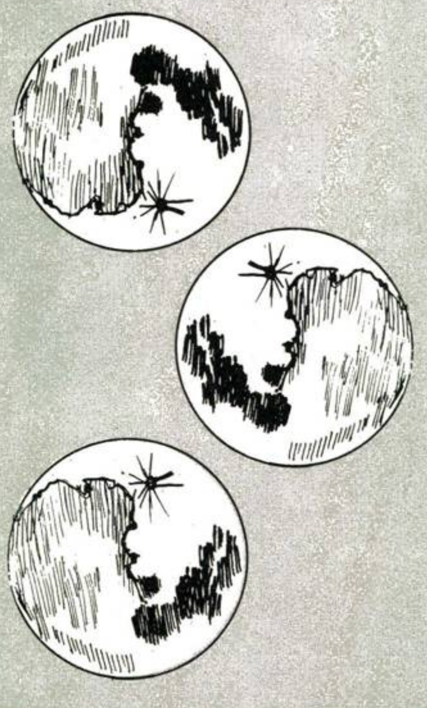
The resulting disorientation sometimes makes it difficult to relate what we see through the main or finder eyepiece to what we see when we look directly at the sky or use binoculars. It also makes it difficult to compare what we see with our maps and charts.

To deal with this optical phenomenon, let's look at the Pleiades as an example. We'll not only learn something about the way telescope lenses and mirrors orient images, but we'll also learn by name the ten brightest stars in that asterism.

If you look at the Pleiades with binoculars, you'll see a type A image.

Note that Asterope is a double star, so although there are ten main stars, there are only nine names. Also note that Pleione and Alcyone are almost due east-west of each other. (The difference in declination is only two minutes of arc.)

Pleione and Atlas are to the left, Celaeno and Electra to the right, the Asterope pair is up, and Merope is the lowest one of the ten. The image is erect and direct, just the way it looks in the sky.



Now suppose that you are looking at the Pleiades through a refractor, using a "straight-through" eyepiece holder, and that the eyepiece has a wide enough field of view to get the entire group inside its borders. What you will see is a type B image.

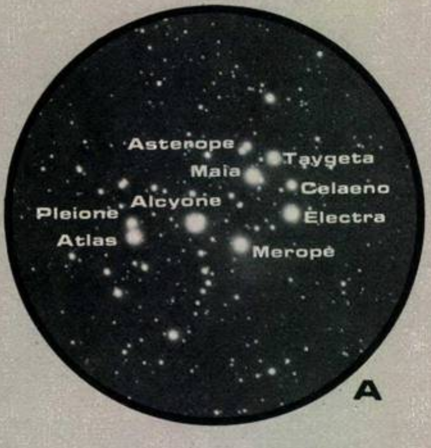
It is as though the star field had been impaled upon a pin at Alcyone and rotated in its own plane 180° about that point. North (Asterope) is now down, south (Merope) is now up, east (Pleione) is to the right, and west (Electra) is to the left. You'll get exactly the same orientation if you use an ordinary refracting finder with a straight-through eyepiece holder. The image is inverted, but it is still direct.

Now suppose you have a right-angle eyepiece holder on your refractor or on your refracting finder. This time you'll get an entirely different image orientation — one that looks like type C.

Not only is everything upside down as before, but now right and left are reversed, too! The image is both inverted and reversed. You would also get this same sort of view — a type C image — with a tri-schiefspiegler or a stationary eyepiece Newtonian.

If you have a conventional Newtonian or a conventional Cassegrain, you'll get a type B image — up will be down and right will be left, etc. However, if you have a Newtonian and you rotate the tube in its cradle to get the eyepiece into a more convenient position, you'll end up rotating the image in its own plane. The amount of image rotation will depend upon how much you rotate the tube. If you rotate it a full half turn, you'll wind up with a configuration identical to A.

The popular catadioptrics — Schmidt-Cassegrains and Maksutovs — will yield a type B configuration if they are used with straight-through eyepiece holders, but since you often use a right-angle holder with them, you usually wind up with a type C image. Triple mirror telescopes — the tri-schiefspieglers and stationary eyepiece Newtonians (variations from Russel Porter's "Springfield" mounting) also produce type C images. The Herschels, who didn't use



A

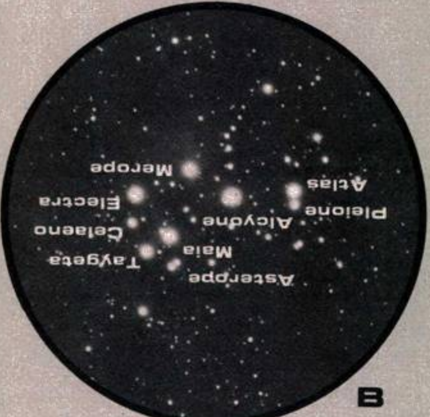
diagonals on their reflectors, tipped the main mirror to bring the image near one side of the open end of the tube and also got type C images.

You can make B look like A by simply turning the page upside down. But no amount of rotating or shifting of the image will make C look like A. There are only two ways you can accomplish this. First, you can hold an ordinary mirror at right angles to the plane of the paper, with the bottom edge below C. Then, in the mirror you will see a configuration exactly like A. The other thing you can do is to turn the page over end for end and then look through it. Again you'll have a configuration identical to A.

Without knowing anything about ray tracing, you can tell by a simple empirical rule whether an image will be erect or inverted, direct or reversed. The key is to count the number of reflections which take place between the sky end of the telescope and the eyepiece. If the number of reflections is zero (as in a refractor with a straight-through eyepiece) or an even number (usually two, as in a conventional Newtonian or Cassegrain — or in catadioptrics using straight-through eyepieces), the telescope forms a type B image — one which is simply inverted but not reversed. If the number of reflections is odd (one, as in Herschelian reflectors and in refractors using right-angle eyepiece holders; or three, as in catadioptrics using right-angle eyepiece holders, tri-schiefspieglers, and stationary eyepiece Newtonians), the image is always reversed and may or may not also be inverted — type C.

Of course, the selection of a telescope shouldn't be governed by the type of image it produces — a reversed image can be just as high-quality as a direct one. The important thing is to keep from getting confused. One simple step in that direction is, whenever possible, to use a finder which produces the same type image as does the main telescope. For example, my telescope is a stationary eyepiece Newtonian and it yields a reversed image. Although my finder came equipped with both a straight and a right-angle eyepiece holder, I always use the right-angle one.

Admittedly it is awkward to try to relate a reversed image to a star chart. And it doesn't do a bit of good to rotate the chart and try to read it upside down! Some observers have tried turning their charts over and shining a strong light through them, but this technique has several drawbacks. First of all, it requires that the charts be unbound, which rules out all book-type atlases. Second, the light has to be strong to shine through that heavy chart paper — and even if the light is covered by a red shield, you inevitably shine it into your eyes and spoil whatever dark adaptation you have achieved. And finally, there's a very practical problem: You never have enough hands anyway, and if one is holding a chart and the other is busy with the light, you'll have to turn the eyepiece focusing knob with your teeth! But even if you don't mind that, all the letters and numbers on the charts are upside down and backwards.



B

I've heard of some observers who keep a plane mirror at the observing site — to place at a right angle to their charts. This works after a fashion, but only with respect to the star configurations — the printing is still upside down and backwards in the mirror, and again, such a technique requires at least three hands.

The approach that I have found most helpful is not to try to use big charts at the eyepiece in the first place. There are at least two other things that you can do. One is to use the 3" x 5" Astro-Cards. These are available in several series and collectively they cover a lot of sky, including most of the more prominent deep-sky objects. Directly, they don't do much about the reversed image problem, but they are easy to handle at the eyepiece. All you need to do to get your graphic data to agree with your optical data is turn the card over and shine a red light bulb through it. Of course, the printing will be backwards, but at least the star configurations will match what your scope and its finder are showing you.

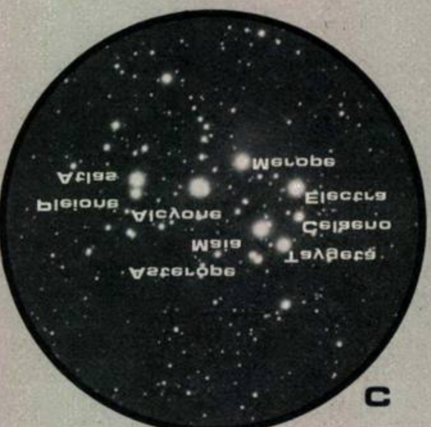
To make this easier, I built a light box with a red light bulb inside — a device I can manage with one hand. And before I use these cards at the telescope, I hold them face down against a window pane and print on the reverse side the Bayer letters and Flamsteed numbers of the stars shown.

These Astro-Cards are fine for the objects which they cover, but there'll be times when you'll want to find something for which there is no card. Recently, for example, I have been trying to spot Encke's Comet. I had an ephemeris so I could plot its path on the charts of my Skalnate Pleso Desk Edition (black stars on white sky). On any particular morning, though, I was only interested in a limited portion of the sky and I didn't want to work with a big white chart at the eyepiece.

To get around such situations, I use tracings of the sky area that interests me. Using a pad of 9" x 12" sheets of tracing paper cut into quarters, I simply make a tracing from the Skalnate Pleso chart which covers that particular part of the sky. Then I turn the tracing over and letter in the star names and numbers and other data that I'll need to know.

Since tracing paper is flimsy and hard to handle by itself, I got a couple of clip-boards, cut a 4" x 5½" hole in one, took the clip off the other and reinstalled it on the first board at the opposite side of the hole from its clip. I clip the opposite ends of the minichart to the board with the reverse orientation up. I can hold this gadget in one hand and read the chart against almost any source of light — like the Astro-Card light box.

A little advance planning, of course, is necessary, but, as we've seen, the problem of image orientation can be solved. And you'll be surprised at how much easier, faster, and more pleasant your observations will be with charts that actually correspond to what you're looking at.



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USING THE LPR FILTER

- For best results with your LPR Filter, use a low power, wide-field ocular (as you would for Deep Sky observing without the filter). Since the LPR Filter is designed to block specific wavelengths of light (primarily from mercury and sodium vapor lights), it is not effective against moonlight. So, for best performance, observe with the filter when the Moon is down. The LPR is not effective in increasing the transparency of smog polluted or cloudy skies.
- Experienced amateur astronomers will appreciate the benefits of this filter more than newcomers to astronomy. As a novice gathers more visual observing experience the real joy and the capabilities of using the filter will become apparent.
- All interference or LPR Filters have a slight amount of wedge inherent in the design. This creates a faint defocused ghost image on very bright stars but this is of no concern since the objects that this filter was designed to observe or photograph are made up of faint stars or gas.
- The Human eye is most efficient in detecting faint objects when it is fully dark adapted. Since the eye won't become fully dark adapted where there is a lot of light pollution, it will help if you shield your eye from extraneous, ambient light when observing through an LPR filter.
- When using the LPR Filter for astrophotography you will have to increase your exposure time by a factor of two or three to record *stellar* objects to the same density as without the LPR Filter. Emission nebulae will be recorded to the same density on your film in approximately the same time with or without the LPR Filter. Longer time exposures are possible because your film will not fog from the bright sky light.
- Due to the spectral response of a typical Celestron LPR Filter, the light from an emission nebulae that is transmitted through to your film (or eye when used in a visual mode) is largely unchanged in its quality (spectrum). This means that color photography will yield an image of nearly natural color balance. Your choice of film and its reciprocity characteristics may alter the color balance more than the LPR Filter. Other apparent color changes can be caused by the lack of artificial radiation, background continuum, and minor nebular emissions that are filtered out by the LPR Filter.

CARING FOR YOUR LPR FILTER

Other than occasionally cleaning your LPR Filter, no special care is required; store in a cool, dry, dust-free container.

To clean the LPR Filter, first blow off any loose dust or dirt particles with compressed air or a squeeze-bulb. Then brush lightly with a camel's hair brush any particles left. Then using a clean, white Kleenex tissue or cotton ball and a solution of 1/3 alcohol and 2/3 distilled water, wet the tissue and gently wipe the filter until it's clean. In cleaning the LPR you may notice hairline sleeks, small scratches, pits, etc. These are normal in the manufacture of this complex design.

TYPICAL TRANSMISSIONS OF LPR FILTERS

Desirable transmission lines, photo-visual filter:

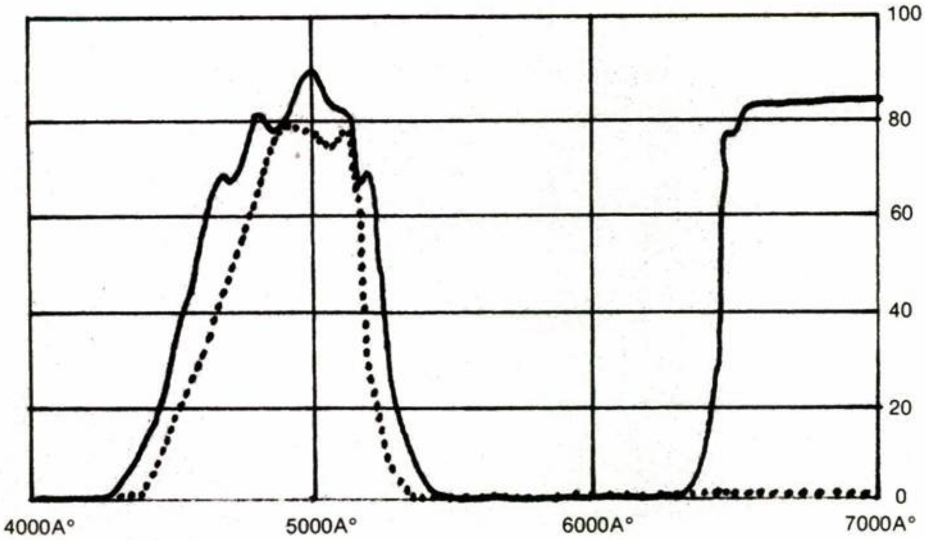
Hydrogen Beta — 4861A°
Doubly Ionized Oxygen — 4959
Doubly Ionized Oxygen — 5007
Hydrogen Alpha — 6563
Singly Ionized Nitrogen — 6548
Singly Ionized Nitrogen — 6584

Desirable transmission lines, visual LPR:

Doubly Ionized Oxygen — 4959A°
Doubly Ionized Oxygen — 5007

Rejection lines (all LPR's):

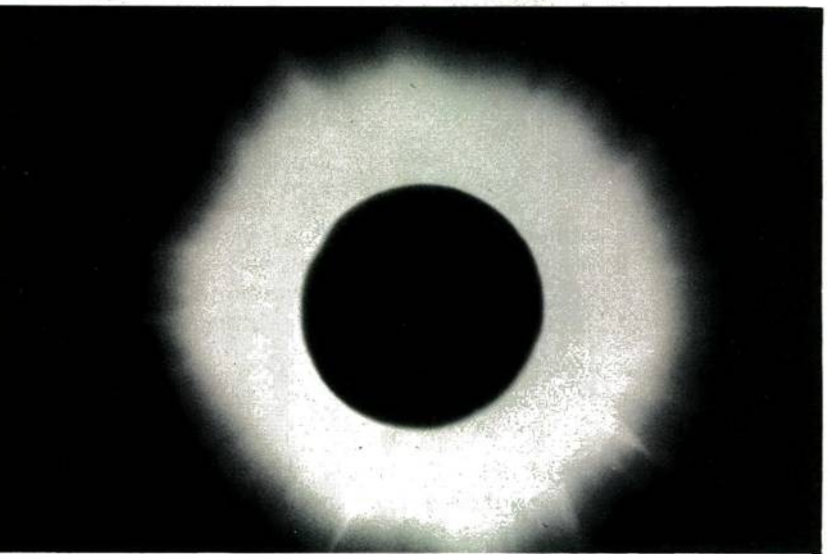
Mercury — 4047°
Mercury — 4358
Mercury — 5461
Neutral Oxygen — 5577
Mercury — 5590
Mercury — 5770
Sodium — 5890
Sodium — 5896
Neutral Oxygen — 6300
Neutral Oxygen — 6360
"Deluxe White" Mercury lines — 6100-6200
High pressure Sodium continum — 5600-6200



TYPICAL CELESTRON LPR FILTER
SPECTRAL RESPONSE

Note: Solid line is for LPR filter models #1, 2, 7
Dotted line is for LPR filter models #3, 4, 5, 6

Celestron International 2835 Columbia St., Torrance, California 90503. Telephone (213) 328-9560



STAR & SKY HAWAII/ ECLIPSE CRUISE

Sail into the path of totality -in the North Pacific- on July 30, 1981!

On February 26, 1979, millions of Americans watched as the moon's disc covered the sun, producing nature's superspectacular – a total solar eclipse. But the celestial clockwork has ordained that America will not be placed under the moon's shadow again for 36 years. Last year eclipse-chasers travelled to Africa and India to see the spectacle. Since total solar eclipses can be witnessed somewhere on Earth about once a year, we decided to sail into the path of totality in the North Pacific on July 30th.

Be among the special group of people who will view a total solar eclipse from the decks of a 30,000-ton 682-foot luxury liner at sea. ***Star & Sky Expeditions*** has contracted the SS Oceanic Independence, of American registry, for the sole purpose of seeking the awesome darkness at midday.

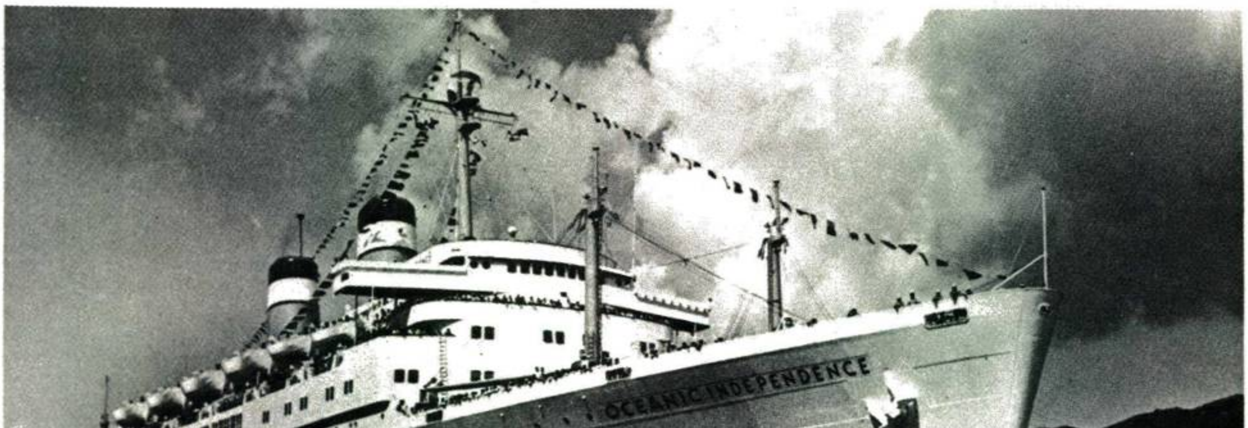
The 14-day cruise includes the voyage to and from the eclipse site, approximately 1200 miles northwest of Honolulu. ***This location has better than an 80% chance of clear skies*** *– SUBSTANTIALLY BETTER THAN ANY OTHER LOCATION ALONG THE PATH OF TOTALITY.*

The eclipse-viewing will be followed by a *5-day Hawaiian Island cruise,* making ports-of-call on the islands of Kauai, Maui, Hawaii, and Oahu.

Our scientific staff is the finest ever assembled for an eclipse cruise: ***Bart Bok,*** formerly professor of physics, Univ. of Ariz., and director, Steward Observatory. ***John Eddy,*** senior scientist, High Altitude Observatory, Boulder, Colo., and solar expert and author. ***William J. Kaufmann,*** adjunct professor of physics, San Diego University, and author of nine books on astronomy and relativity. ***James Sadler,*** head meteorologist, Univ. of Hawaii. ***George Keene,*** senior engineer, Eastman Kodak, and astrophotography expert. ***Terence Dickinson,*** editor, *Star & Sky*. Our cruise director is ***Robert T. Little,*** Field Sales Manager for Criterion Scientific Instruments, veteran of three eclipse cruises and seven Astronomy Island cruises to Bermuda, pioneer of solar-eclipse photography at sea.

Space for this incredible eclipse cruise is limited so you must act now. Prices start at $2,000 per person, double occupancy, plus airfare. Detailed information is available in our brochure which can be obtained, along with a free copy of our 1980 eclipse issue, by writing to:

Star & Sky Expeditions, Inc.
44 Church Lane
Westport, CT 06880



Voyager Telescope

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The Voyager 6001 is equipped to accompany the earthbound naturalist by day; by night, earthly boundaries are transcended as Voyager 6001 provides clear, sharp images of the evening sky. The smooth rack and pinion focusing mount accepts all RKE® eyepieces, allowing magnification from 17X to 81X. The 5X 24 mm finderscope with a cross-hair reticle helps locate elusive celestial objects.

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Perfect for game and target observation, the Voyager 6008 is optimally refined for land use. A straight-through image erector creates right-side-up images, correctly oriented from left to right. The sleek light-weight design makes it a natural for any outdoor activity. You'll see incredibly sharp and detailed images of birds, animals, flowers, even insects, in their natural habitats, while leaving them entirely undisturbed. The Voyager is literally a long distance microscope!

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And Voyager 6008...

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AstroNews

Site of Space Telescope Institute Chosen

The Association of Universities for Research in Astronomy, Inc. (AURA) manages the operation of Kitt Peak National Observatory, site of the largest collection of optical ground-based telescopes in the world. It also operates the Cerro Tololo Inter-American Observatory in Chile and the Sacramento Peak Observatory in Sunspot, New Mexico.

Now AURA, a consortium of 15 universities, has been selected by NASA to establish and operate the Space Telescope Science Institute. This major astronomical research center, where astronomers will receive data electronically from the orbiting Space Telescope and its five auxiliary instruments, will be housed in a yet-to-be-constructed building on the campus of Johns Hopkins University in Baltimore, Maryland. The Institute building is expected to cost approximately $8 million (current dollar value). Johns Hopkins has offered land and financing for the building, including a contribution of $2 million toward the cost of its construction. The remainder of the building's cost will be reimbursed by AURA through lease payments over a 15-year period.

The Space Telescope, a cooperative project of NASA and the European Space Agency, is already two-thirds built, and NASA plans to launch it from the Space Shuttle in early 1986. It will be placed in orbit 370 miles above the Earth and will radio its celestial signals through the NASA communications network to the Goddard Space Flight Center in Greenbelt, Maryland. Goddard will also house the Science Support Center (SSC), an arm of the institute which will also be under the management of AURA. Observers at the institute will communicate via intercom with the telescope's operating engineers and astronomers at SSC.

According to AURA President Dr. John Teem, "The new Space Telescope will greatly expand the number and distance of objects for astronomical study. Because there is no atmosphere to interfere, it will be able to resolve objects five to ten times smaller in angular resolution than ground-based optical telescopes. This ability, plus spectroscopic and photometric instruments on the telescope, will enable us to look considerably further back in time — into the early evolution of the universe."

To obtain the precision required for astronomical observations, the telescope has been designed to have the most accurate "pointing" ability of any previously put into space.

The 43-foot long telescope will have a 96-inch primary mirror and will be accompanied by five auxiliary instruments to assist in obtaining astronomical data. Present plans are to bring the telescope down approximately every five years for major refurbishment, which could include putting new instruments on board or giving the mirror a new reflective coat. Minor maintenance will be done by astronauts while the telescope remains in orbit.

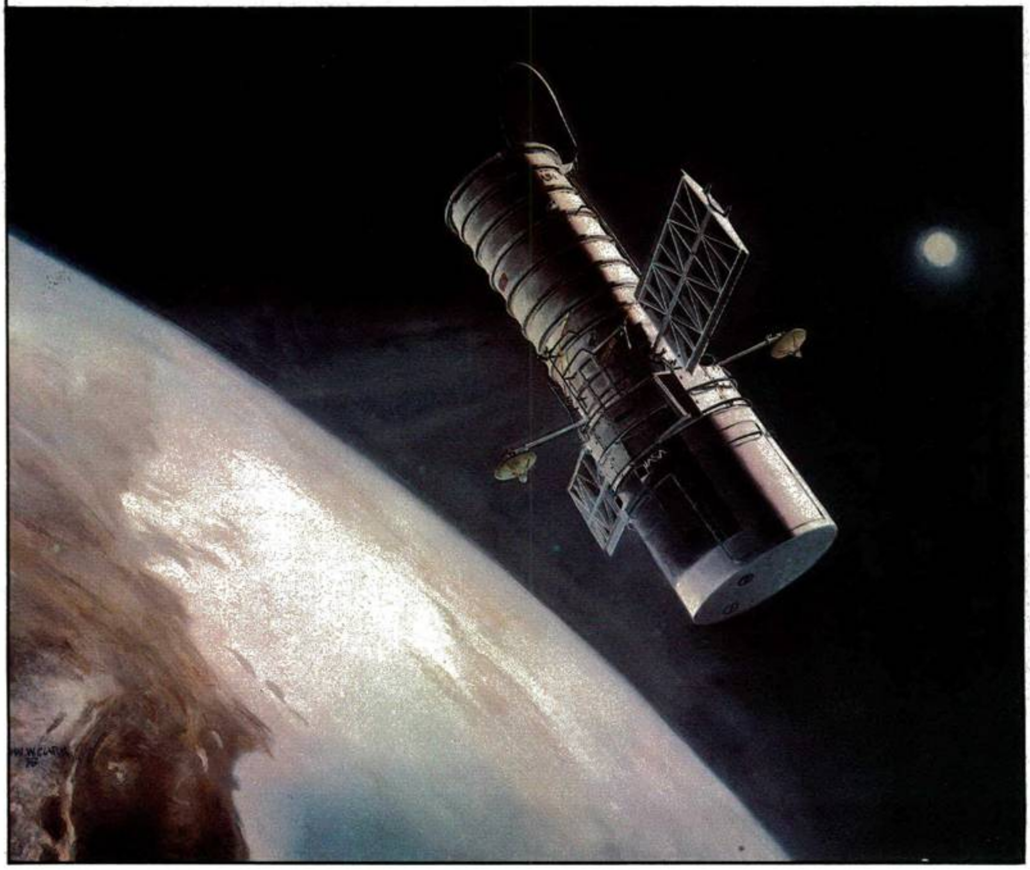
As manager of the Institute, AURA will:

- Hire the director and support personnel to ensure effective operation of the data display and analysis equipment at the Institution,
- Evaluate observing requests and select those with the greatest scientific promise, and
- Administer the estimated five-year budget of about $25 million (current dollar value).

AURA's initial contract with NASA is for a five-year period, and includes the option for three extensions of five years each.

Observations at the Institute will continue around the clock as astronomers will no longer need to wait for dark or be concerned about such things as cloudy skies or light pollution from our cities. "We estimate that the Institute will build to a staff of about 185, including approximately 40 astronomers, when it is at full operation," explained Dr. David (Kelly) Welch, corporate staff executive of AURA.

The Space Telescope is scheduled to be launched in 1986. Artwork by John Clark.



Johns Hopkins and AURA will provide some temporary staff members to help get the Institute under way quickly. Dr. Arthur Code, from the University of Wisconsin and one of AURA's board members as well as its former board chairman, will serve as acting director of the Institute while the permanent director is being recruited.

One of the main reasons AURA decided to locate the Institute in Baltimore was the city's proximity to the Goddard Space Flight Center in nearby Greenbelt. This will permit more efficient operation since staff members may easily commute to either the SSC or the Institute facility, allowing ready rotation of assignments and assuring staff familiarity with operations at both sites. This location will also facilitate effective interaction and communication, both of which are prime considerations for the team effort this operation requires.

Will the Space Telescope replace the need for or use of ground-based optical telescopes? The answer is a definite no. Instead, its results will stimulate many follow-up or concurrent research programs which require the use of ground-based telescopes all over the world and their considerably larger number of sophisticated auxiliary instruments.

In Dr. Teem's words, "We in AURA believe that the Space Telescope is one of the most exciting additions to astronomical research capability that we will see in this decade. We are eagerly looking forward to participating with NASA and intend to make the Institute the kind of place that the astronomical community needs, and expects to have, to utilize this Space Telescope effectively."

Part of the constellation Cygnus appears in this plate from the original National Geographic Society / Palomar Observatory Sky Survey.

A New Sky Survey

The California Institute of Technology will begin a new photographic survey of the northern sky, using its 48-inch Schmidt telescope at Palomar Mountain Observatory. The survey, conducted with funds from the National Geographic Society, the Alfred P. Sloan Foundation, and Eastman Kodak, will use improved films that will enable the recording of stars and galaxies four times fainter than objects visible in the last sky survey, completed in 1957. The 1957 survey has been used by astronomers as a basic guide to the celestial objects in the northern hemisphere sky.

"The sky survey conducted between 1949 and 1957 is widely recognized as being one of the most important astronomical developments of the 20th century," said Caltech Professor and Executive Officer for Astronomy Wallace L. W. Sargent, who will oversee the new survey.

"Without it, many of the most spectacular developments in contemporary astrophysics would have been either impossible or seriously impeded. The sky survey enabled swift optical identification of interesting objects, a large proportion of which were initially discovered via their intense radiation at radio, X-ray, or infrared wavelengths." These objects include distant radio galaxies, quasars, and clusters of galaxies.

The new effort, which will take several years, will consist of photographing about 700 overlapping areas of the entire sky north of the celestial equator, in both red and blue wavelengths of light. The 48-inch Schmidt telescope at Palomar Mountain is the best choice for the survey because of its large size, wide field, and ideal siting. The project will complement a similar survey of the southern sky now underway at the European Southern Observatory in Chile and the UK Schmidt telescope in Australia. Reproductions of the photographs will be made available to astronomers all over the world.

The basic reason for the new survey is the development of new films with finer grain emulsions having a higher storage capacity. Another survey of the sky will be carried out simultaneously in the infrared region of the spectrum.

The new survey will be used to aid several other major astronomical efforts over the next decade. It will help guide the use of the Space Telescope to be launched in 1986, and will be used to optically identify objects detected by ground-based radio telescopes and infrared and X-ray satellite observatories.

To fund the effort, the Alfred P. Sloan Foundation has granted $350,000; the National Geographic Society, $300,000; and Eastman Kodak, $90,000, plus all the necessary photographic products. A portion of these funds will be used to modernize the 48-inch Schmidt telescope. Caltech will contribute the cost of using the telescope for the approximately 700 nights of observing required for the survey.

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On to Uranus!

NASA has officially approved the continuation of Voyager 2 on a trajectory which will take it to Uranus in 1986 after flying past Saturn this summer.

Under the approved plan, the spacecraft will encounter Uranus at a distance of 107,000 kilometers (66,000 miles) on January 24, 1986, making measurements and taking pictures as it speeds past and heads for a possible encounter with Neptune.

The Uranus encounter will provide the world with its first close-up look at the planet. Uranus is the seventh planet outward from the Sun, twice as far from the Sun as Saturn. A cold, grim world, it rotates on its axis at a tilt of 98° to the plane of its orbit.

AstroNews

The decision to fly past Uranus is, in effect, a decision to retain the present trajectory. If agency officials had decided against a Uranus encounter, then a retargeting of the Voyager 2 would have been required.

Voyager 2, launched August 20, 1977, is a sister ship to Voyager 1, which recently provided a historic close-up encounter with the ringed planet Saturn. Voyager 2 flew by Jupiter in July 1979 and will encounter Saturn on August 25 of this year.

Voyager 1's trajectory through the solar system was selected to optimize the scientific objectives at Jupiter, Saturn, and Titan. The path of Voyager 2 was chosen to provide a course to Jupiter, Saturn, and Uranus, and perhaps Neptune. This path does not provide a close-up approach to Titan or a Saturn ring occultation which were among the goals of the Voyager 1 mission. The final decision to remain on this trajectory had to await the successful outcome of Voyager 1's close encounter with Saturn and Titan, which went off without a hitch this past November.

Voyager 1 has achieved all of the prescribed Saturn/Titan scientific objectives. The assessment of the health of the Voyager 2 spacecraft and instruments indicates that there is a reasonable probability that the five-year journey to Uranus can be endured and a scientifically productive flyby can be achieved.

"On this basis, therefore, the decision has been made to retain the present Uranus trajectory of Voyager 2," said Andrew J. Stofan, Acting Associate Administrator for Space Science. He pointed out that retargeting of the spacecraft to provide another close Titan flyby could have been made as late as early 1981.

Quasars and Galaxies

Astronomers have found new evidence to support the idea that quasars, widely believed to be the most distant observable objects in the universe, are disturbances in otherwise normal galaxies.

Galaxies are not distributed uniformly throughout the universe, but occur in clusters of up to a thousand members or more. If quasars have the same origin as galaxies, astronomers have reasoned, they should have the same distribution. But until recently, none of the 1600 quasars so far discovered had been observed within a prominent cluster.

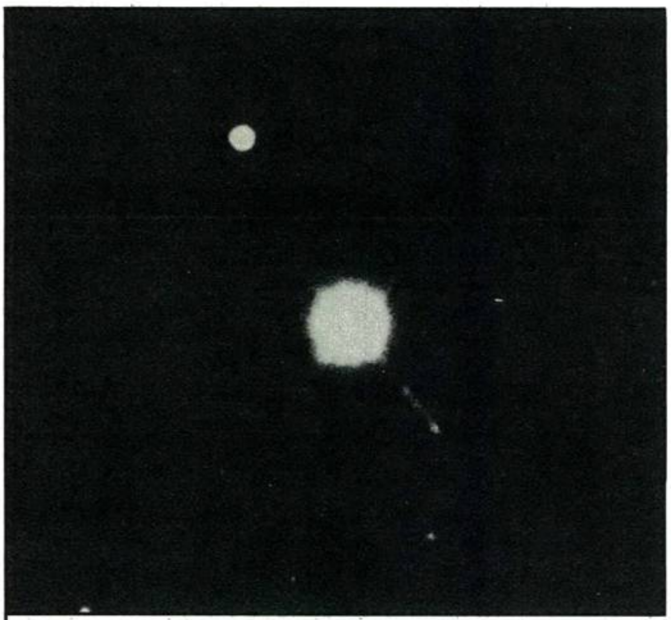
Now, astronomers believe they have evidence of two quasars occurring within a cluster of galaxies. The observation was made by Dr. Bruce Margon, professor of astronomy at the University of Washington; Dr. Gary A. Chanan, assistant professor of physics at Columbia University; and Ronald A. Downes, graduate student in astronomy at the University of California-Los Angeles.

Quasars, or quasi-stellar objects, are as bright as thousands of galaxies yet apparently occupy no more space than a single star. The source of energy is a mystery — although some astronomers think quasars may be massive black holes that slowly gobble up stars within a galaxy.

The observations by Margon and his associates occurred almost by chance. They were studying a well-known quasar, dubbed 3C-345, using the X-ray telescope aboard the Earth-orbiting Einstein Observatory. A photograph of this quasar revealed a second source of X-rays nearby.

"It could have been a star," says Margon. "We took a look at its spectrum, using the 120-inch telescope of the Lick Observatory at Mt. Hamilton, California. That confirmed it was a quasar."

The new quasar (called 1641+3998, after its celestial coordinates) is approximately the same distance from Earth as 3C-345. More exciting, the distance between the two quasars is exactly the size that a cluster of galaxies would occupy. "Unless nature is mischievous," says Margon, "we are seeing the two brightest members of a galaxy cluster. The quasars are almost surely related."



New evidence suggests that quasars, such as 3C-273 shown above, may in fact be the brightest members of distant clusters of galaxies. Kitt Peak National Observatory photo.

Margon is optimistic that his observation will lead to the identification of other quasars within clusters of galaxies. "At least we know now," he says, "that quasars don't avoid clustering. Astronomers are coming to regard clustering as a fundamental statement concerning the evolution of matter in the universe, a result of the turbulent events following the Big Bang. This observation is reassuring in that regard."

The Einstein Observatory played a key role in making this observation possible. X-rays can't be observed from Earth because they are blocked by the atmosphere. The Einstein Observatory, launched two years ago, is 100 times more powerful than any previous X-ray telescope. It is a key tool for observing objects at the edge of the universe, such as quasars. These two quasars are estimated to be approximately ten billion light-years from Earth.

Margon and his associates have discovered 40 other quasars using the Einstein Observatory, but they have not yet found another located in a cluster of galaxies. "If we've found one, there should be more," says Margon. "By coupling X-ray astronomy with optical techniques, I'm sure more will be identified."

Meteorite Symposium

How important is the Moon in the study of Earth's history? What can one meteorite which fell in Mexico teach us about the birth of the solar system? Did meteorites play a role in the extinction of dinosaurs? How safe is Earth from falling meteorites? What are the chances of towing asteroids?

These and other questions will be discussed when prominent scientists in the fields of meteoritics and planetary sciences assemble for a major symposium at the American Museum of Natural History in New York City on Wednesday, April 29.

The symposium, open to the general public, will precede by one day the opening of the Arthur Ross Hall of Meteorites. This new permanent exhibition is named for museum trustee Arthur Ross, who has been a significant supporter of museum projects and exhibitions. The symposium will include experts from American universities and government science agencies.

"The study of meteorites is important because it gives us a greater knowledge of how the Earth was formed," explains Dr. Martin Prinz, chairman of the museum's

Department of Mineral Sciences and scientific consultant to the new hall.

Guest speakers include Dr. John A. Wood of the Smithsonian Astrophysical Laboratory and Harvard University, Dr. Lawrence Grossman of the University of Chicago, and Dr. Gerald J. Wasserburg of the California Institute of Technology.

Dr. Wood, who has devoted his career to studying meteorites and the Moon, will discuss the quantum leap in knowledge about the planets and solar system since 1969 when man first walked on the Moon.

Dr. Grossman, whose theories on the development of meteorites have gained considerable recognition among his peers, will explain why meteorites provide clues to the development of planets. He will concentrate on the research regarding the famous Allende meteorite which fell in Mexico in 1969 and which has been an important resource in the study of the solar system's origins.

Dr. Wasserburg will comment on planet development theories. Considered one of the most prominent persons in the field of planetary sciences, Dr. Wasserburg has perfected and developed systems for determining the age of objects falling from space and has used these systems to gain insights into the creation of planets and the solar system.

"The Sky is Falling" is the subject of a talk by Dr. Eugene Shoemaker, a member of the U.S. Geological Survey's astrogeology branch in Flagstaff, Arizona, and a professor at the California Institute of Technology. Dr. Shoemaker, a pioneer in meteorite impact studies, will explain the effect, frequency, and cause of meteorites hitting the Earth, Moon, and other planets.

Falling meteorites will also be discussed by Dr. Donald Brownlee, a member of the astronomy department at the University of Washington and a research associate at the California Institute of Technology. Dr. Brownlee will describe how meteorites are collected from ocean floors, land, and even the upper atmosphere.

Other speakers include Dr. Clark R. Chapman, a member of the University of Arizona's Planetary Science Institute, who will lecture on the origin of meteorites; Dr. Ronald Greeley, also of the University of Arizona, who will give a "grand tour" of the planets by describing photographic findings of Saturn, Jupiter, Mars, Venus, Mercury, and Earth; and Dr. Noel Hinners, director of the National Air and Space Museum in Washington DC, who will comment on the future of planetary sciences and intriguing concepts such as asteroid towing.

For more information contact:

American Museum
of Natural History
Central Park West at 79th Street
New York, NY 10024.

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NOV. 80
TITAN CITY

Spaceweek 1981

For a week last summer, a coalition of space enthusiasts brought the potential of outer space down to Earth and into local spotlights by celebrating Spaceweek. This year they are planning a broader sweep across the country to promote the benefits of space, and are seeking nationwide support for their efforts.

The July 1980 Spaceweek attracted people by the tens of thousands and reached millions more with the message that mankind's future is in outer space. Spaceweek involved NASA, aerospace companies, small businesses, professional groups, clubs, and civic associations. Week-long festivities were held in Houston and Los Angeles with smaller events in other cities. Designed as an annual celebration, Spaceweek culminates on July 20, the anniversary of man's first step on another world.

Spaceweek's proponents hope that it will be the catalyst of a national pro-space movement. Influencing the nation's leaders today, as did the environmentalists in the 60s and 70s, requires extensive — but not expensive — use of the media and a "grass roots" base.

Spaceweek's operation is media-intensive. The week's events include exhibits, space "voyage" nights, lectures, a rocket meet, telescope star parties, a banquet, and other events with popular appeal. This forms the basis for a vigorous media campaign of news releases, newspaper and broadcast interviews, press parties, and live coverage. In Houston last year the message of outer space benefits was seen or heard an estimated 3.3 million times. The entire effort, primarily volunteer-oriented, had a surprisingly low budget.

Spaceweek isn't another space society, and it doesn't seek members. Its goal is rather to bring together all pro-space groups in an annual, highly visible push for the exploration and utilization of space. The organization doesn't sponsor events, but encourages pro-space groups to do so.

Spaceweek is currently seeking individuals, organizations, and companies across the country which are willing to help sponsor a Spaceweek observance in their communities this coming July. Individuals involved in Houston's Spaceweek '80 have put together a guidebook for local Spaceweek directors, event planners, and publicity committees. This guidebook will be sent to individuals willing to organize activities. Spaceweek is also seeking donations and support from corporations and other institutions which favor greater NASA funding and a more positive public attitude toward space.

Persons desiring more information on Spaceweek '81 can write to:

Troy Welch
Spaceweek National
Headquarters
P.O. Box 58172
Houston, TX 77058

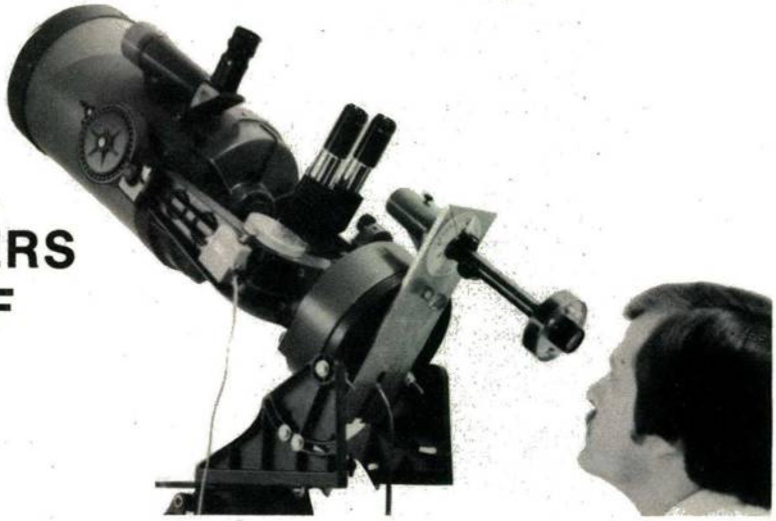
State in your inquiry the kind of involvement you seek (leader, follower, donor, etc.) and the name of the metropolitan area (if any) you are near. For greater effectiveness, Spaceweek will help get people together who are in the same area.

Amateur Directory

James Gall, the editor of the *Astronomical Directory*, is now preparing a new edition of this handy international guide to astronomical institutions, observatories, libraries, organizations, and amateur astronomers.

He asks that any individual or organization wishing to be included in the new directory write to him at:

Gall Publications
1293 Gerrard St. East
Toronto, Ontario M4L 1Y8
Canada



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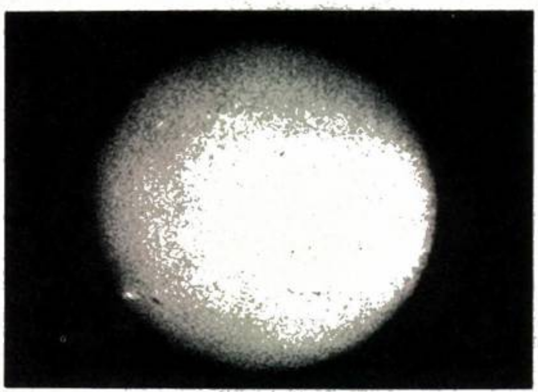

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ASTRONOMY REVIEWS

Cosmos
Carl Sagan and KCET, producers
13 hour-long episodes
Directed by Adrian Malone
Public Broadcasting System (1980)

My wife prophesies that Carl Sagan will emerge from his 13-part series *Cosmos* as the supernova sex symbol of the season. "He has everything today's woman wants," she declares, "warmth, compassion, sensitivity, an absolutely fascinating mind. Yet there's nothing intimidating about him."

I find the host and co-writer of this $8 million public television venture to be the personification of what every college freshman dreams of finding — a professor so brilliant, so vibrant with his subject, so lovingly devoted to his students, that learning becomes a joy.

The clear precedent for the series is the late Jacob Bronowski's splendid *The Ascent of Man* in the early 1970s. But while Bronowski spoke as a grandfatherly mathematics professor, Sagan is a youthfully handsome 46-year-old, with such glamor credentials as a Pulitzer Prize and NASA medals for work on the Mariner, Viking, and Voyager missions to the planets.

He also has the advantage of speaking on astronomy and space exploration, subjects newly dazzling to millions of viewers of such movies as *Star Wars* and *The Empire Strikes Back.* Through him, however, the empire that strikes back is the empire of science — a realm he sees as dangerously misunderstood and maligned. "In *Cosmos,*" he says, "we have tried to speak not just to the mind but also to the heart...We aim to show that an appeal to the spirit, a resonance with deep human emotions, a delight in music and art *are all* consistent with — indeed a fundamental part of — the scientific enterprise."

And so he arrives on our television screen, this astonishing old-shoe genius, campus-casual in turtleneck shirts and lumpy parkas, radiating warmth like a long-lost roommate. He is, among other things, one of the most spell-binding talkers as well as quite possibly the best teacher ever to bless TV. He seems to speak, at first, with pedantic slowness. Soon, however, one recognizes an intellectual sharpshooter, making haste slowly, never wasting a word, wielding gestures and emphasis with the intensity of a revival preacher. All with that same gentle, caring smile, and never a hint of condescension.

The format of the show is "a 10-billion light-year journey from the far reaches of the universe to Earth," via such complex special effects as an enormous futuristic spaceship. With our good doctor at the glittering control console, we explore such eerie wonders as the broiling red surface of Jupiter, the rings of Saturn, the Orion Nebula, and the surface of Mars — even skirting the great Olympus Mons volcano and racing down the canyon of Vallis Marineris, a chasm more than 10 times the length of the Grand Canyon.

As electronic music swells with choirlike poignance, he leads us gently on, a scientific high priest speaking calmly of the 30 million years required for someday's spaceship to reach the center of our own Milky Way Galaxy, of the 8 or 10-billion light-year distance to the most distant quasars. He finds our planet "floating like a mote of dust in the morning sky," shockingly insignificant amidst the cosmic grandeur. Yet just as mood music climaxes in a throat-tightening requiem for all us humans lost aboard tiny, threatened Spaceship Earth — there is Sagan, grinning up at the starry heavens like a boy cheering eternity's greatest light show.

Jay Scriba
Reprinted courtesy of
The Milwaukee Journal

*****

The astronomer sits at his telescope, whose mirror reflects the light of the visible spectrum, bringing him unalloyed vistas of celestial knowledge and beauty. The home viewer sits in front of a television set, washing his eyes with dots of colored light emitting (frequent) nonsense and (occasionally) fascinating and valuable information. Carl Sagan's TV series *Cosmos* is a welcome contrast to the usual TV fare — and is thus a beginning for what many hope will be a global awakening to the glories and wonders of our vast universe "in which we float like a mote of dust in the morning sky."

Unfortunately, however, the series begins with Sagan in $400 Gucci shoes stepping into his dandelion "Spaceship of the Imagination" as a rather embarrassing cross between Captain Kirk and Sallmann's *Head of Christ*. While honeyed, over-enunciated sonorities drone, a faint smile forms at the corner of Sagan's haloed profile as he passes his hands over the children's building block controls of the spaceship.

For the uninformed viewer, the scale of galaxies, quasars, and stars presented in this opening is undoubtedly confusing. The point of the Cosmic Calendar, though clarified in the second episode, is initially lost. As an excited witness of awesome sights, Sagan is unconvincing, and much of his audience surely got irritated or bored and turned to another channel.

In content, Sagan is basically sound, though speculative, in the sciences. When he moves into the humanities, however, he stumbles frequently and badly, possibly the result of his unfamiliarity with the revolution wrought by Friedrich Nietzsche, as crucial a thinker in these areas as Einstein is in science.

Like most scientists, Sagan is

unreliable on the classic Greek thinkers. He jumbles together men separated by centuries, and fails to see that the pre-Socratics were *philosophes*, not proto-scientists. And the "mystic" Pythagoras is not only the direct ancestor of Kepler's obsession with perfect circles, but also of Stephen Hawking's obsession with black holes. Such an obsession has very little in common with Sagan's "scientist" Anaximander.

His history is also simplistic. While the destruction of the Alexandrian library may be a symbol, it is hardly a major cause of the so-called "Dark Ages." These failings are important because of the cosmic intentions and pretensions of this series.

In astronomy, however, such disappointments as clouds, wind, cold, and dust are common. One learns to wait for better weather and clearer skies. In the case of *Cosmos*, the patient viewer is rewarded with stunning pictures and remarkable stories: an explanation and illustration of Eratosthenes' determination of the size of the Earth's circumference; a dramatization of the stiff-necked theoretician Kepler's discussions about planetary motions with the gold-nosed observational genius and raconteur Tycho Brahe; a reenactment of the observation by Canterbury monks of a massive explosion on the Moon in June 1178; the portrayal of the Viking lander's amazing automated experiments on Mars; thrilling time-lapse photos of Jupiter's swirling clouds; a description of Huygens' determination of the brightness and thus the distance of Sirius.

There are other high moments: the story of the Heike crab in Japan whose carapace evolved an image of a warrior's face; a startling simulation of how a comet might look striking the Earth; historical film footage of the damage in Siberia from some mysterious gigantic explosion in June 1908; the comparison of the flying boats of Dutch explorers with the Voyager probe; a Brooklyn child's view of the stars as "probably farther away than New Jersey"; the metaphor of the planets as campers around a fire; the tasty use of the theme music, *Le Sacre du Printemps*, *Carmina Burana*, Holst's *Planets*, and other pieces in the background (but where's the space rock music?).

It is refreshing, also, to hear Sagan's pro-ecology and anti-war sentiments. His frequent reminders of the repressiveness of religion *vis a vis* scientific discoveries are likewise salutary, though one wonders if his often vague mumbo-jumbo has the counter unintended effect of encouraging childish credulity among Americans prone to such in any case.

Finally, however, we have too much of Sagan and his infertile imagination, and not nearly enough hard information and beautiful photographs of celestial sights. Special effects and *Star Wars* art make impressive visuals, of course, but hardly match the breathtaking images which have the unsurpassed advantage of being real. In science, the real always exceeds the imaginary. It's in art that the reverse is true — and Sagan too often forgets his scientific calling.

More than halfway through the thirteen shows, it has become clear that the series is stuck with partly cloudy skies. Sometimes the view is high and steady; sometimes it's quite murky. People out there are starved for knowledge of the marvels among the planets and stars. We've found they respond quickly and enthusiastically to brisk factual presentations of such actual wonders. *Cosmos* has such moments, but far too often the pace slows to a reverential crawl. Still, it's superior to stale news shows and paranoid cop and horror programs. Tune in to the reruns, at least if the weather prevents any firsthand outdoor viewing.

Stephanie and John Mood
San Diego, CA

Journeyman Machinist en Route to the Stars
Oscar Seth Marshall
156 pages, hardcover, $12
William S. Sullwold Pub. Co. (1979)

While browsing through a local bookstore recently, my wife happened across Marshall's *Journeyman Machinist*. And, knowing my astronomical interests, she bought it for me.

The first part of the book recounts the author's early life, training as a journeyman machinist, marriage, and his frustrated attempts at higher education. Marshall then accepted a job and lifestyle commensurate with his education, but somewhat out of character with his true qualities.

About halfway into the book, Mr. Marshall's friendship with Russell Porter surfaces, leading into the founding of the Springfield Telescope Makers and the establishment of Stellafane. The association with Porter developed into a lifelong friendship, and was a key factor in the selection of both men by George Ellery Hale to participate in the design and construction of the famous 200-inch telescope on Mount Palomar.

In the final pages of the book, the author reminisces about his life and things that might have been, but most of all, about the blessings and beauty of the real world in which he lived.

Journeyman Machinist is profusely illustrated. As the reader progresses, the author's mundane, matter-of-fact style of writing slowly becomes more free-flowing and descriptive, revealing the true nature of his ability and character. This book gives its reader an insight into a bygone era where the qualities of character, craftsmanship, involvement, and purpose made possible so many of the things we take for granted today. *William H. Black.*

Cosmology and Gravitation
Peter G. Bergmann and Venzo De Sabbata
510 pages, hardcover, $65
Plenum Press (1980)

One of the NATO Advanced Study Institutes Series, this volume includes papers presented by the lecturers at the Institute on Cosmology and Gravitation held at the Ettore Majorana International Center for Scientific Culture in Bologna, Italy, May 6-8, 1979.

The papers are highly technical and mathematical, definitely not for those uninitiated into the deeper mysteries of gravitation and elementary particle physics. The volume reflects the current interest in the quest for a unification of the various kinds of physical interaction, with particular emphasis on the mathematical structures involved in this quest. A substantial number of the papers deal with possible experimental tests of current theoretical formulations.

Dictionary of Astronomy
Iain Nicholson
250 pages, paperback, $4.95
Barnes & Noble (1980)

Reprinted from the author's 1977 hardcover book, the *Dictionary* defines about 1500 terms relating to astronomy and space science. When you look up one term, the extensive cross-referencing leads you on to related ones.

Grosses Lexikon der Astronomie
Joachim Herrmann
406 pages, hardcover, DM 59.80
Mosaik Verlag (1980)

Anyone who can read German will find this a fat, profusely illustrated and useful encyclopedic dictionary of astronomy. The closest thing to it in English is the (out-of-print) *ABC of Astronomy* by Weigert and Zimmermann — another book translated from German. Maybe, someday, a U.S. publisher will translate this....

The Fallen Sky

by Charles Pellegrino

About 65 to 90 million years ago, near the close of the Cretaceous period, fully one quarter of all known animal families and an uncountable number of plants vanished from the fossil record. This disappearance took place during the "short" span — short, at least, in geological and biological terms — of a few million years, at the Cretaceous/Tertiary boundary, and marks one of Earth history's most striking episodes of biological revolution and mass extinction.

The victims of this great worldwide upheaval (called by some scientists "the terminal Cretaceous event") included several varieties of clams, and almost all the brachiopods, sea creatures which looked like clams. Many nautiloid species died out, as did their cousins the ammonites. Accompanying them in their demise were oceanic plankton, certain fishes, and the most famous of the now-extinct species, the dinosaurs. Not even the insects, often regarded as an ancient and invariable class of animal, emerged unscathed.

Since the Cretaceous extinction included the largest and best known animals ever to roam the continents, it has been the focus of much inquiry. At times, the search for causes has been a sort of scientific parlor game, and the flood of speculative reasons advanced so far could easily fill a fat book.

Most of the proposals remain unconvincing because they are usually applied to the dinosaurs exclusively. Many theories, typically, dwell on problems arising from the dinosaurs' large size — food supply, mobility, coordination — despite the fact that many dinosaurs were smaller than today's house cats.

Every five years or so, someone proposes (in all seriousness!) that dinosaurs had poor taste buds and thus couldn't detect the bitter, poisonous alkaloids in new species of flowering plants. These theories skip over the question of how giant sea-going reptiles, little clams, and single-celled amoeba-like animals also became extinct.

In recent years catastrophic models for extinction, particularly those attributed to extraterrestrial causes, have become popular. These include nearby supernovae, fluctuations in the Sun's energy output, and asteroid or large meteor impacts. And why not? After all, we know stars explode with devastating consequences for light-years around. We strongly suspect the Sun's output has varied, even over human history, and suspect larger variations over "geological" time. And lastly, we're certain that impacts — big ones — sculpted the landscape long ago.

Interest in the asteroid theory has been aroused by the findings of a team headed by Nobel laureate Luis Alvarez and his geologist son, Walter, at Berkeley, California. Searching for a standard element to measure the deposition rates of sediments, the Alvarez research group had hoped to use iridium.

Iridium, like other heavy, unreactive metals in the platinum group of elements, is very rare in rocks of the Earth's crust and upper mantle. What little iridium went into the Earth's make-up during its formation has probably sunk to the core. By contrast, iridium's abundance in unmelted, undifferentiated stony meteorites is a thousand to ten thousand times greater than that of the Earth's crust.

Working on the hypothesis that most iridium found in terrestrial sediments comes from extraterrestrial sources — and that it arrives in meteorites and cosmic dust as a fairly constant, worldwide "rain" falling from space — the Alvarez group reasoned that sediments rich in iridium must have been exposed to this rain for a long time and had formed slowly.

Theoretically, this idea sounded fine, but right from the start it didn't seem to work as it should have. The first measurements made on rocks from the Umbrian Apennines of Italy gave results far too high (30 times the average) assuming a steady influx of iridium. Samples taken near Copenhagen, Denmark were even more disconcerting: iridium was 160 times more abundant than expected.

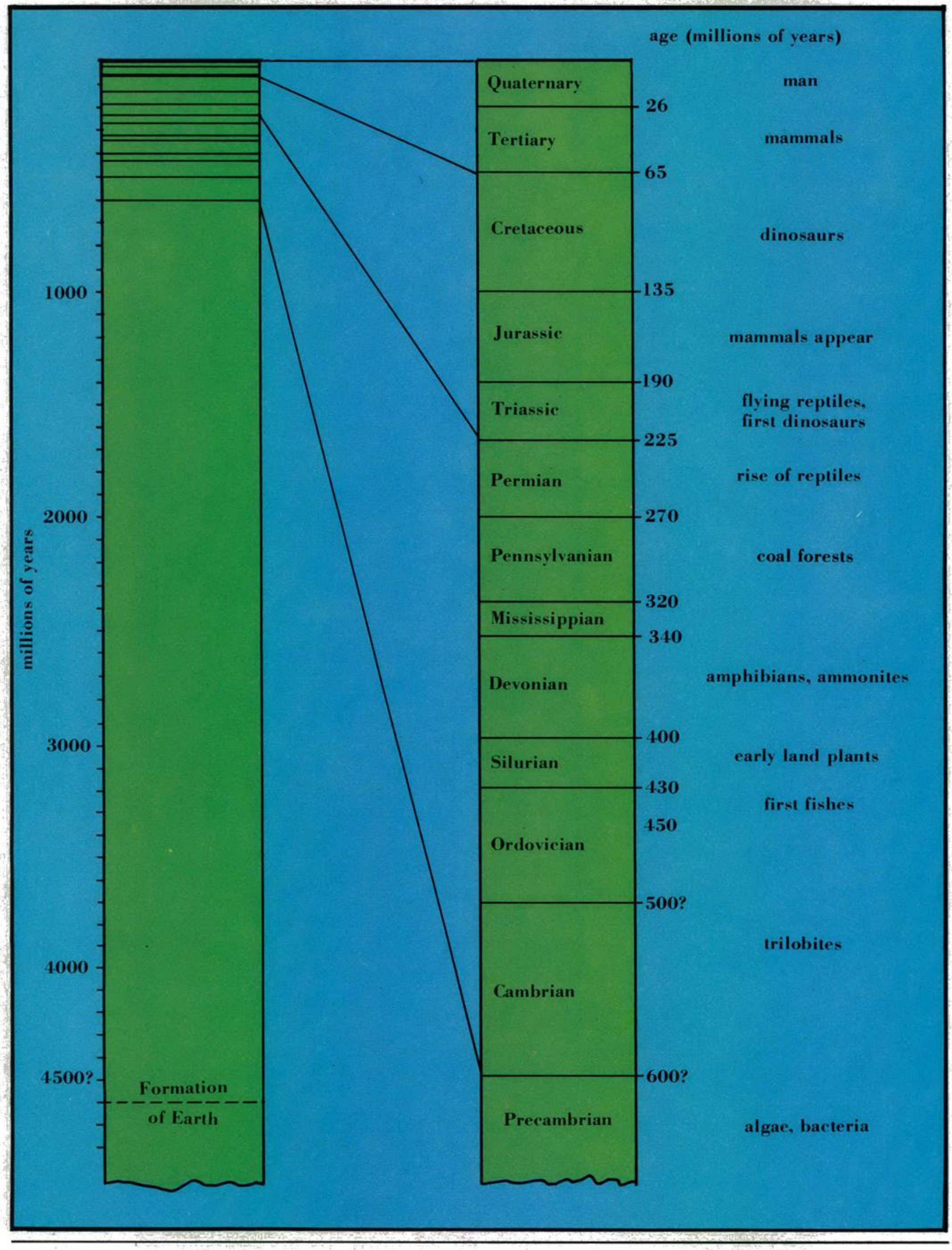
Both samples had come from thin clays deposited at the Cretaceous/Tertiary boundary, coincident with the great extinction — and the connection excited considerable scientific and some popular attention.

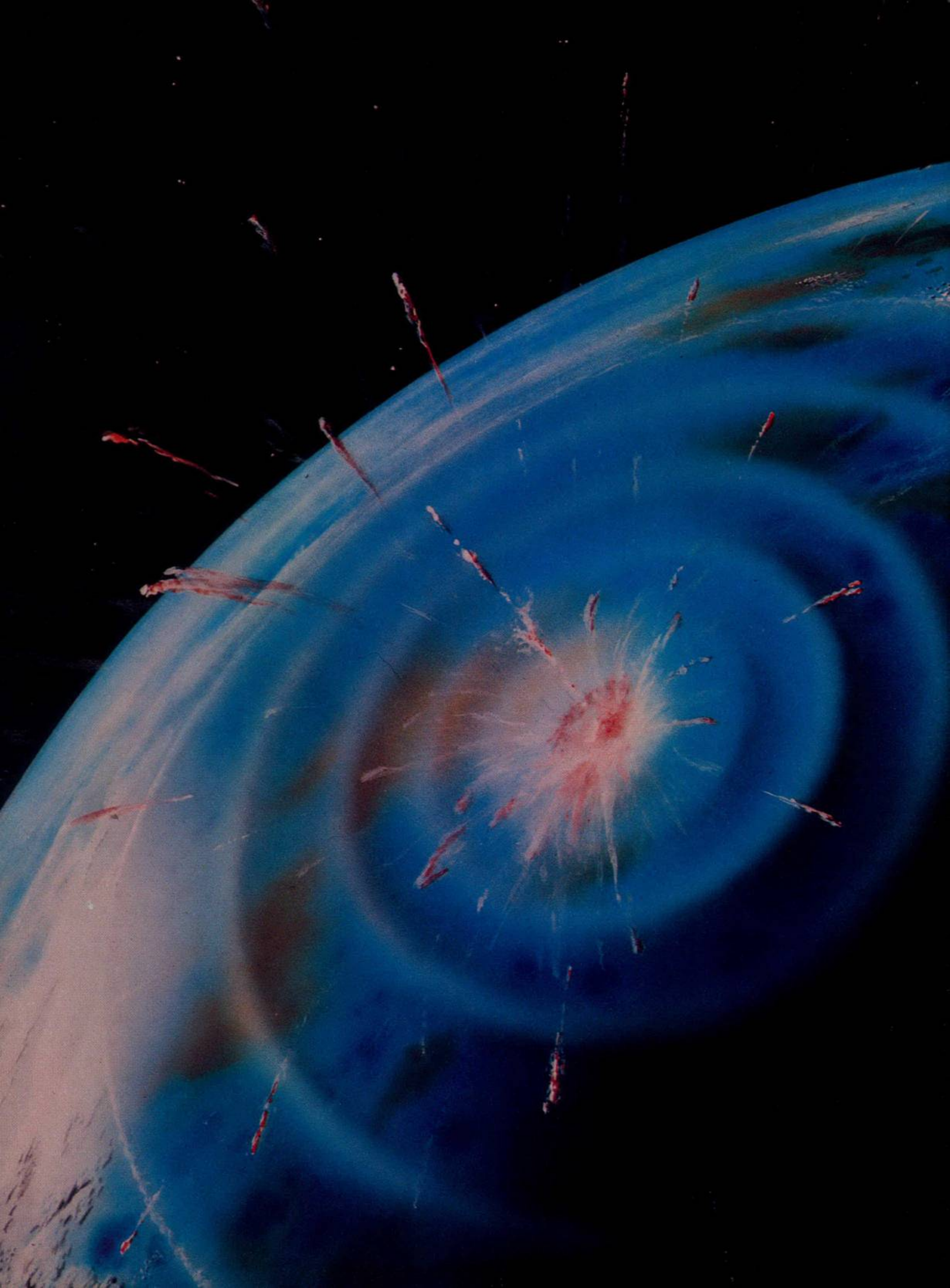
To account for the excess iridium, the Berkeley investigators propose that vast quantities of it arrived at the end of the Cretaceous period in the form of an asteroid the size of Manhattan. Such an object would have slammed into the Earth's surface at approximately 32 kilometers per second and belched more dust into the atmosphere than several hundred Mount St. Helens eruptions. They suppose that dust would have darkened the atmosphere over the entire planet, shutting down photosynthesis and collapsing an orderly global ecology.

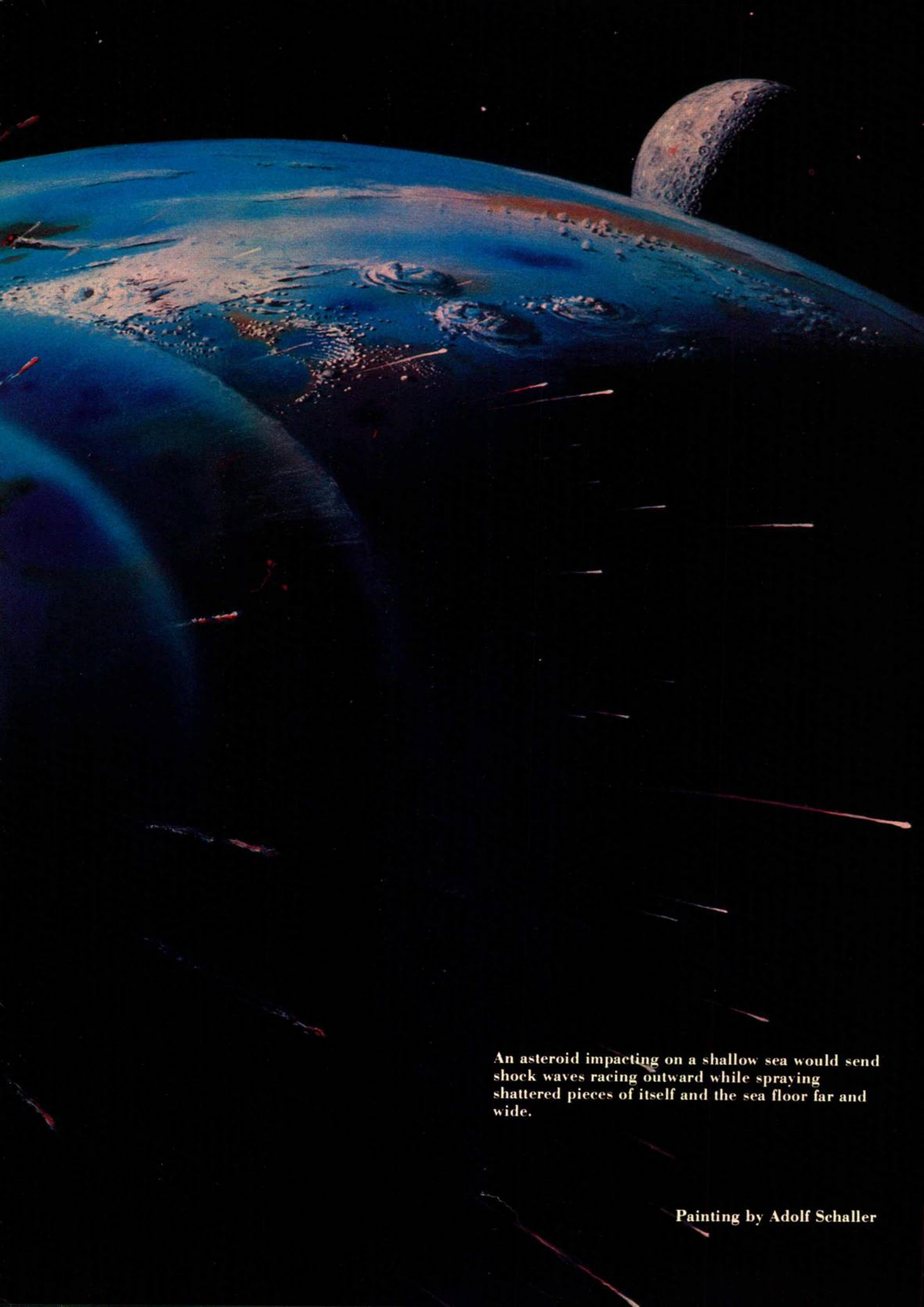
While there's little doubt the Alvarezes have found evidence for an asteroid impact at the close of the Cretaceous, blaming the plight of dinosaurs and their contemporaries on that one event may be apportioning the blame too narrowly.

Their "ten years of darkness" scenario is on shaky ground geophysically and might not stand up if the asteroid

The Geological Time Scale



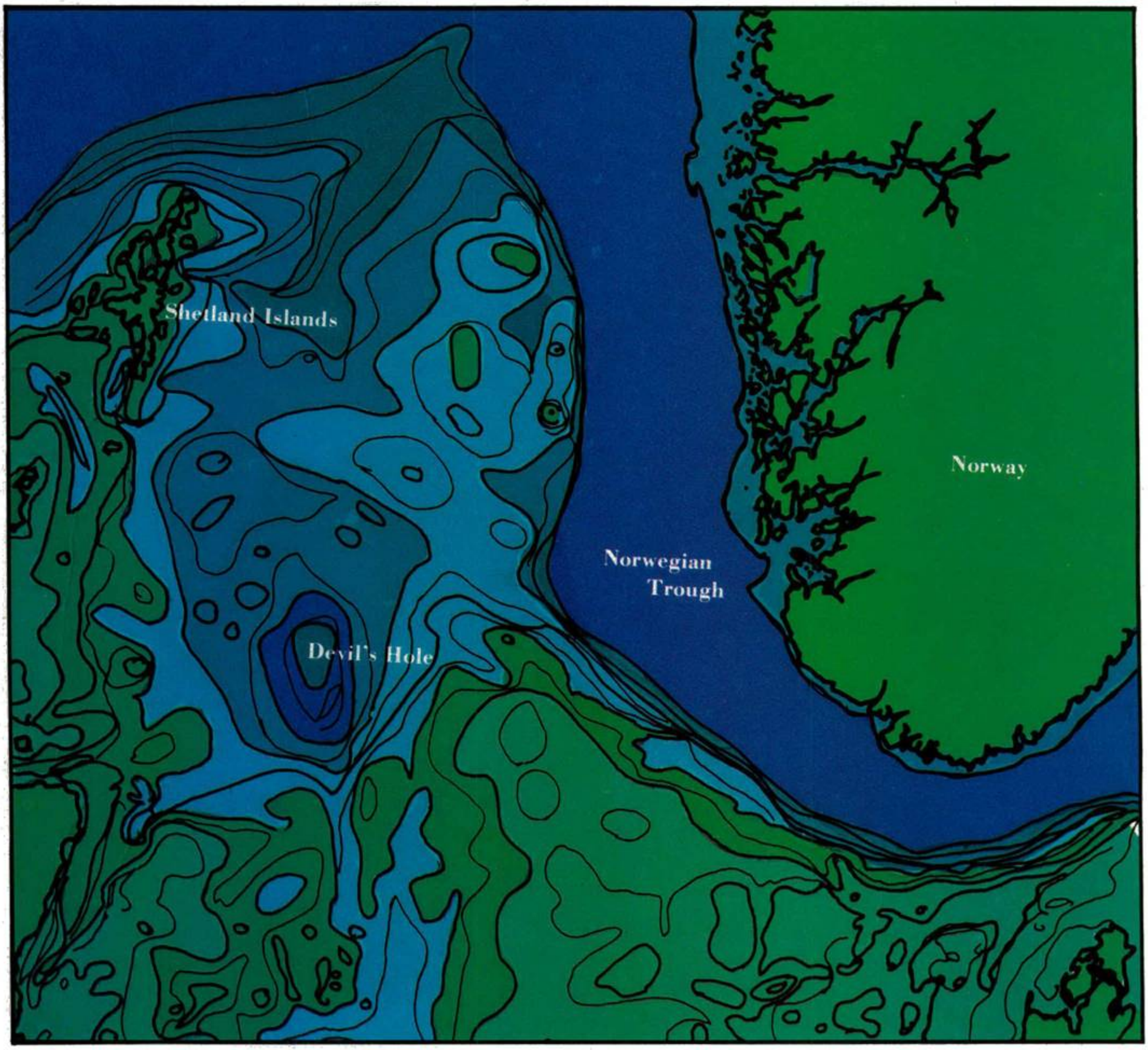




An asteroid impacting on a shallow sea would send shock waves racing outward while spraying shattered pieces of itself and the sea floor far and wide.

Painting by Adolf Schaller

The North Sea Floor



impacted on water — which the odds favor three times out of four. Moreover, where is it? Erosion can work rapidly, but 65 million years isn't long enough to destroy all traces of a crater a hundred miles or more in diameter.

Currently, although scientists are puzzling over the five-fold disagreement between the Italian and Danish samples, very few people seem to be asking where the crater might be. If the anomalous iridium levels grade away from their source, then they point generally toward the North Sea. There, on the sea floor nearly 325 kilometers east of Dundee, Scotland, lies another anomaly — a 250 meter deep depression known as Devil's Hole. The "hole" forms an almost perfect circle, measuring over 80 kilometers in diameter.

If Devil's Hole was formed by a meteorite striking part of the ocean, its impact would have been great. Much energy from such a strike would transfer immediately to the surrounding air and water, blowing cubic miles of steam high into the atmosphere. The direct, local effects on Europe and a then-considerably-narrower Atlantic Ocean would be spectacular. Certainly it was bad news for anybody underneath — pity any reptilian observer on the western shore of Denmark who might have watched the swift retreat of the sea and beheld a dark, distant shadow that rose in frightful majesty, pushing even the clouds before it....

Over much of the northern hemisphere it would have rained ferociously, but the rains would also have carried most of the churned-up dust to the ground. Only stratospheric particles would linger for any length of time. The net effect would most likely have been a slight, short-lived cooling of global temperatures — and not a darkening of the entire planet.

So, astounding as it seems, even an average-sized asteroid's impact would have little lasting effect, in geological and biological terms, on the entire Earth. And as for mass extinctions, it's doubtful that any one factor can, by itself, be credited — life seems relatively "durable."

Perhaps we are seeing the reverse of what happens when many of the factors in the success of a species (temperature, food supply, moisture, etc.) coincide favorably and a population surge results.

Might the end of the Cretaceous period have been an unfavorable coincidence of events? Climate will probably prove to be the main culprit — not so much a cooling-off as a general decline of equability. Add to this an Apollo/Amor asteroid impact, one or two magnetic reversals, with the associated flood of solar particle radiation, and a slow but profound draining of the continental shelves. Sprinkle this lightly with radioactive elements — the wreckage of a nearby star, perhaps — and things can become pretty hard if you happen to be a dinosaur, or even an insect for that matter.

In invoking solely catastrophic explanations, aren't we forgetting other extinctions that mark the geological record? Certainly, Earth has been hit before: Landsat imagery has confirmed the existence of several multi-kilometer scars, but massive cratering is extremely rare today. The frequency of impacts declined rapidly about 3.7 to 3.9 billion years ago, following the heavy bombardment of the planets and their satellites in the late stages of their formation. Even during the period of intense bombardment, pre-living chemical evolution must have begun in our seas. Impacting asteroids would only have stirred the mixture of water and silt and organic compounds, while at the same time injecting new energy into the system so that by about four billion years ago — perhaps even many millions of years earlier — our most remote ancestors had appeared: microscopic bags of polymer. Perhaps they lacked DNA, but nevertheless they were capable of using certain molecules (the flattened, ring-like porphyrins, for example) for storing and releasing of energy.

During the 500 million years that followed, as asteroids continued to hammer at the Earth, not only did actual living cells evolve, but they also managed to establish complex ecosystems. Some used energy from the Sun to process carbon from the environment, while others devoured their neighbors — and still others took the crucial evolutionary step to multicellularity.

A thought to excite the imagination, to make your scalp prickle, is that these creatures — the things that became us — emerged during the time of our planet's heaviest bombardment, almost literally as it formed from a collapsing ball of gas and dust.

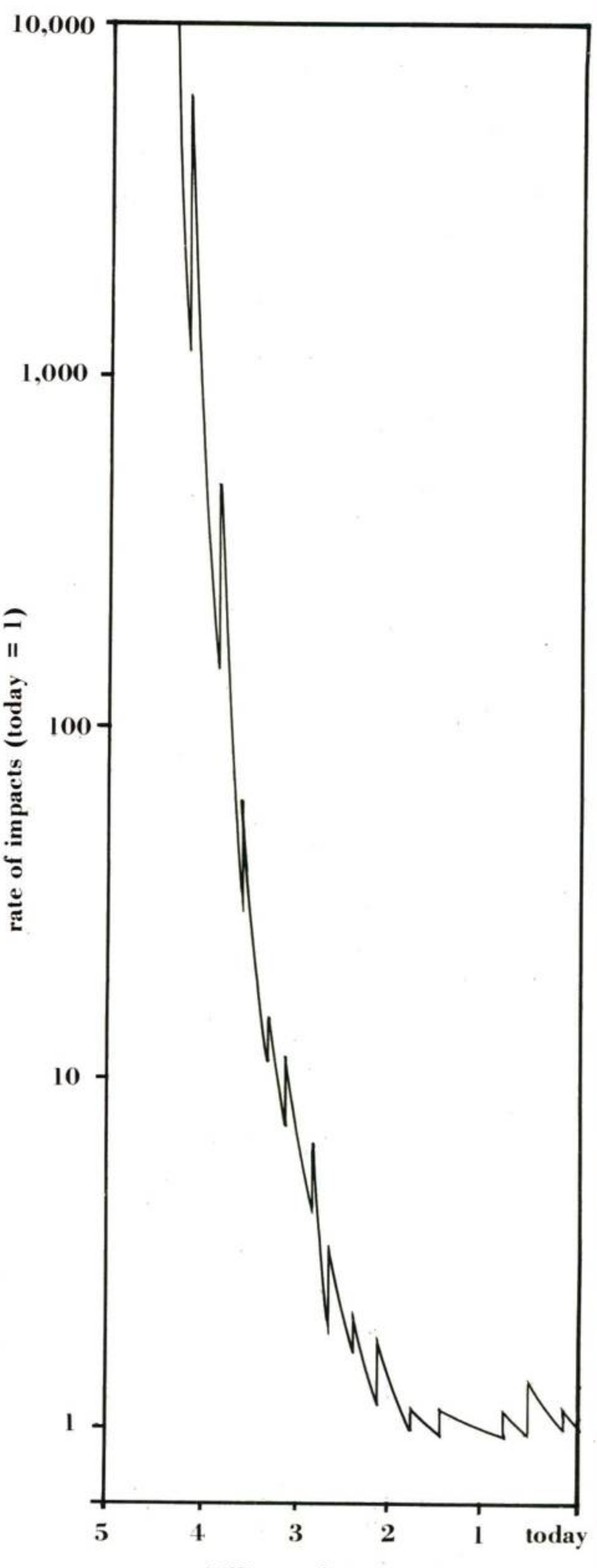
What was the fate of those little bags of polymer and energy-storing molecules? Although extinction appears to be the destiny of most species (caused usually by failure to adapt rapidly enough to changing conditions), these little energy bags or protocells might not have disappeared altogether. The first cells themselves may have evolved from a symbiosis of the simpler protocells and, now equipped with genetic coding systems for their own replication, are living inside every plant, animal, and protistan cell.

Chloroplasts and mitochondria (the microscopic "powerhouse" of living cells), or something very much like them, seem to be the probable candidates for the earliest recognizable life to have appeared on Earth.

Think about this the next time you hold a leaf in the palm of your hand.

Charles Pellegrino is a Ph.D. candidate in zoology at Victoria University in Wellington, New Zealand. He has done research on paleobiology and paleoclimatology, and is now working on a book about chemical evolution, the origin of life, and mass extinctions.

Earth's Cratering History



Impacts dominated Earth's first billion years. Today they are very rare, as this idealized graph shows.

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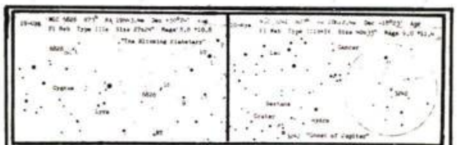

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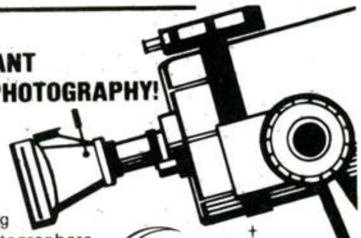

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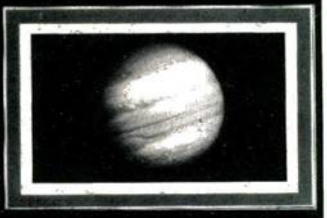

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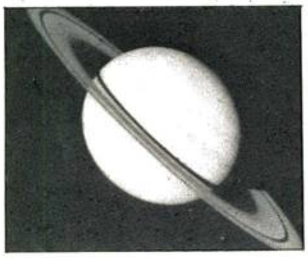

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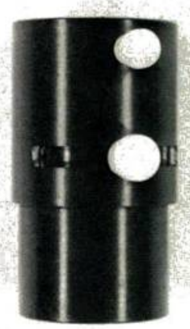

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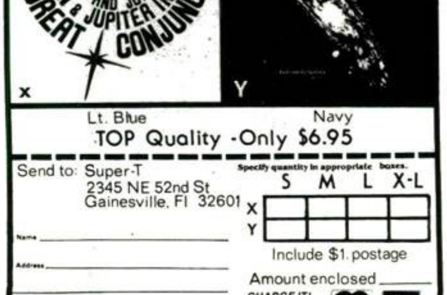
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FOR SALE — Meade 2" O.D. prime focus adapter, $11 ppd.; Meade 20mm Erfle research grade, good condition, $25 ppd.; Novak low profile 2" focuser, rack & pinion, 3" travel, 3-1/4" tall, never used, $38 ppd. Contact Ken Folkins, 12320 210th Pl SE, Issaquah, WA 98027.

WANTED — Correspondence (Spanish or English) with persons interested in 50s and 60s rock & roll music and astronomy. Contact Barbara Vazquez, Av. Reforma 1937, Cd. Juarez, Chih., Mexico; or 114 Finita Ct. #49, El Paso, TX 79907.

WANTED — 13-year-old beginning astronomer would like correspondence with other astronomers and/or astronomy clubs in New York City. Contact Richard R. Roston, 392 Central Park West, New York, NY 10025. Phone (212) 663-4599.

WANTED — Correspondence with British or European college-age person(s), about astronomy and/or soccer; also possible: current music, photography, basketball, or other. Male or female invited. Contact Steve Birge, 385 Kearney St., Ashland, OR 97520.

WANTED — *Canon of Solar Eclipses* (Meeus), *Analytical and Numerical Methods of Celestial Mechanics* (Chebotarev), *Canon of Eclipses* (von Oppolzer). Contact Thomas Kelso, 716 Arbor Dr., Vandenberg AFB, CA. Phone (805) 734-1072.

WANTED — Correspondence with persons (13-17) interested in S.F., music, science, photography, religion, and who are concerned with the future of the world. Any other interests welcome. Contact Brendan Hickey, 915 Raleigh Rd., Glenview, IL 60025.

WANTED — Correspondence with persons (13-16) seriously interested in *Star Trek*, astronomy, and the Space Shuttle. Contact Gene Garrison, 1324 Kildeer St., Round Lake Beach, IL 60073.

WANTED — Hardcover editions of Asimov's *Rest of the Robots* and *Nine Tomorrows*. Send price and condition to Michael Barnett, 783 Colonial Arms Rd., Union, NJ 07083.

WANTED — 3mm Clave Plossi eyepiece. Must be in excellent condition. Contact Joe M. Kroboth, 3179 Parkview Dr., Whitehall, PA 18052. Phone (215) 264-2197 after 4 p.m. EST.

WANTED — Brandt objective lenses, 8"-12-1/2", doublet and/or triplet; also, Aerial lenses useful for astrophotography with good color correction, must be useful without yellow (minus blue) filter (Aero Ektar 178mm f/2.5?) Contact Paul Koczet, Laerheidestr. 28, D-4630 Bochum, West Germany.

WANTED — Correspondence with anyone ages 18 and over interested in astronomy, space science, photography, *Star Trek*, coin collecting, and model building. Contact John DeSanto, RD #1, Box 291, Gouldsboro, PA 18424.

WANTED — Correspondence. Am thinking of buying an 8" Schmidt-Cassegrain or Odyssey 1. Would appreciate hearing opinions on the various brands and dealers. Contact Frank Smith, 122 Line St., Easthampton, MA 01027.

WANTED — Correspondence with anyone, any age, anywhere, interested in planetary, stellar, galactic, and aeronautic astronomy. If you are into astronomy, then our club is for you. Communications made via mial. Contact W. Shuster, 1961 Kaptey Ave., Coquitlam BC, V3K 5Z7, Canada.

WANTED — ASTRONOMY back issues: August 1973 through December 1974, March 1975. Contact Mark Swaim, Rte. 12, Box 104, Winston Salem, NC 27107. Include SASE.

WANTED — Alvin Clark refractor. Send detailed information including size, price, and any photos to Tut Campbell, P.O. Box 723066, Atlanta, GA 30339. Phone (404) 255-0045.

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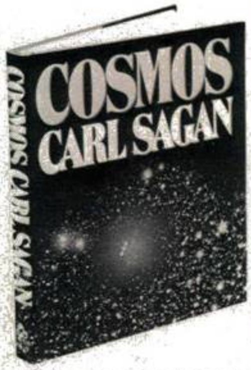
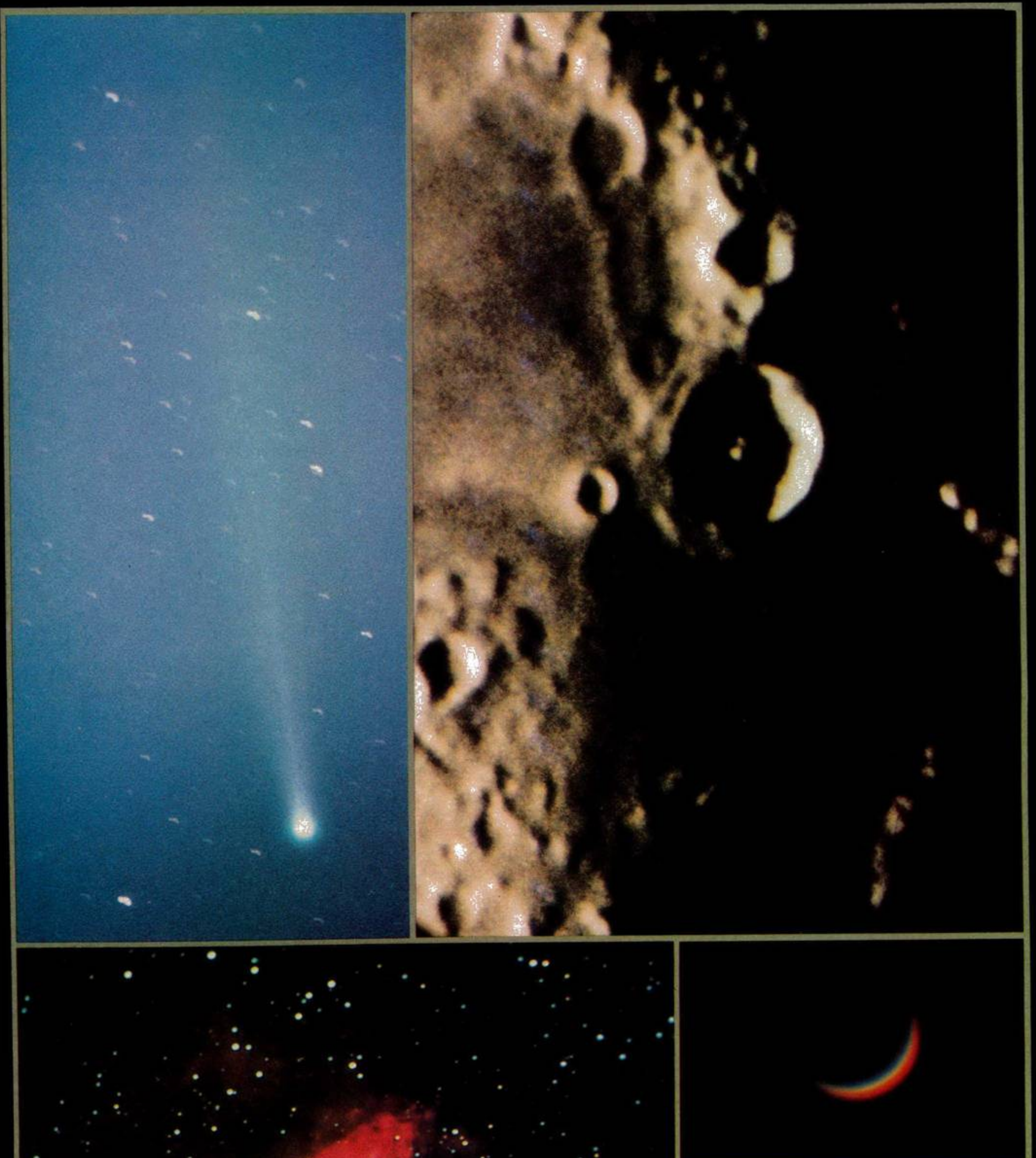


To order, use order form between pages 60-61.



close-up on corvus/crater/eastern hydra

The planetary sights for April run pretty thin: only two bright planets will be visible — Jupiter and Saturn. The others, Mercury, Venus, and Mars, all lie either too close to the Sun or at too low an elevation to be seen without great difficulty. The outer gas giants, Uranus and Neptune, are relatively well-placed for observation. Even Pluto (at opposition this month) may tempt you!

Mercury

The first few days of April offer your best chance to observe Mercury. On the morning of April 2, the Moon, 2½ days before New, will be to the right of it. Because both lie so low in the east, you'll have to look for them in a bright sky immediately before sunrise. At 16h UT on the 27th, Mercury reaches superior conjunction, moving into the evening sky toward its best elongation of the year.

Venus

Venus comes to superior conjunction on April 7 at 9h UT and will be too close to the Sun to be seen until late next month. Then, it will appear low in the west after sunset.

Mars

The Sun finally overtakes Mars this month: conjunction happens on April 2 at 14h UT. It will appear in the east before sunrise by early June.

Asteroids

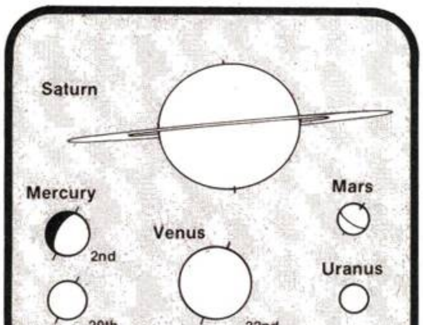
1 Ceres (magnitude 8.0) lies near Castor on Gemini — moving eastward, it passes Castor a little over a degree due south of the star around 2h UT on April 14, and about 2° north of Pollux at 20h UT on the 22nd. Its positions:

10th: 7h 28m 47s, +31° 01.1′
20th: 7h 40m 34s, +30° 25.4′

Ceres sets at around 2 a.m. local time in mid-April.

2 Pallas (9.0) is in northern Eridanus, about 25° south of the Hyades Cluster and about 15° to the northwest of Rigel. Positions:

10th: 4h 08m 03s, -6° 27.2′
20th: 4h 27m 22s, -4° 57.0′



Pallas sets early — about 7:30 p.m. local time on April 15.

3 Juno (10.3) is at opposition on April 20 in Virgo. Positions:

10th: 14h 15m 44s, -1° 16.6′
20th: 14h 07m 58s, -0° 05.7′

Being at opposition, Juno is up for viewing the whole night.

4 Vesta (7.1) is the (visually) brightest of the Big Four; you can find its location by scanning 15m of right ascension west and just less than 2° north from second magnitude Gamma (γ) Leonis. Positions:

10th: 10h 03m 58s, +21° 39.7′
20th: 10h 05m 00s, +21° 12.9′

About a month past opposition, Vesta is well-placed for observations — it lies close to a bright star and is "viewable" nearly all night.

Jupiter & Saturn

On April 3 (at 4:14 UT), Jupiter will pass closely north — 14 arc-minutes — of a 3.9 magnitude star, Eta (η) Virginis. Eta is about as ordinary a star as you could find — it shines colorless white and is neither variable nor multiple — but its proximity to Jupiter and Saturn this year lends it some glory.

By the end of April, Jupiter will lie well to the west of Eta and Saturn is poised to overtake the star — which it does, a degree and a half to the north, on April 30.

During April, both of these gas giants are near their maximum apparent sizes for this observing season (see Planetary Data, page 80). Don't ignore this fine opportunity to get familiar with the belts, spots, zones, and moons of these two planets.

Uranus

This month is a good time to start following Uranus: opposition happens on May 19. If you've been checking up on it regularly, you'll have become familiar enough to find it easily — and perhaps you'll have noted its ponderous motion against the stars in southeastern Libra.

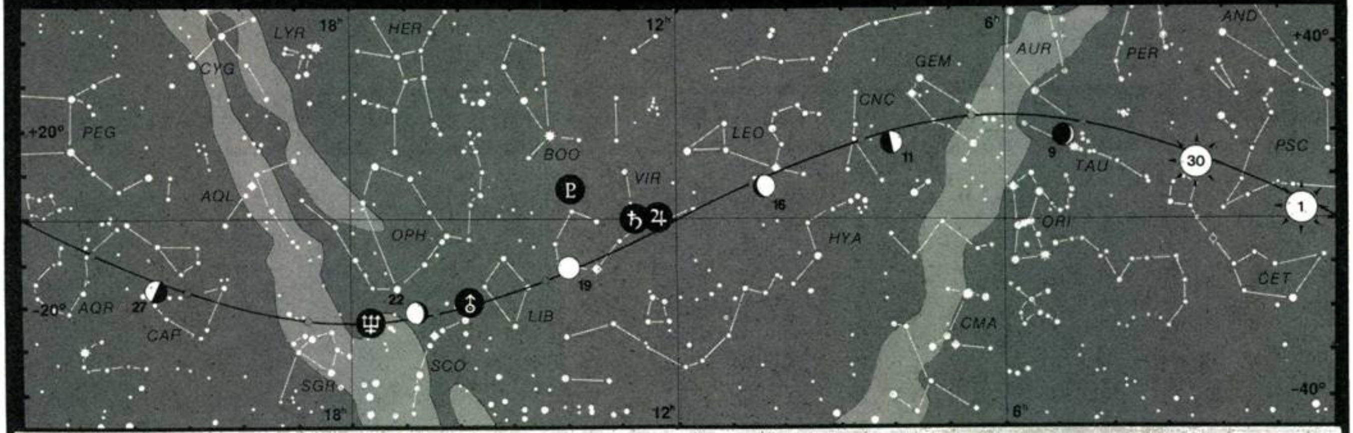
But if you've never found Uranus and observed it with your telescope, start by aiming your scope at Beta (β) Scorpii, a 2.9 magnitude double star. Then scan due west — 13m of right ascension in early April, 17m in late April. Uranus is a magnitude 5.8 object with a diameter of 3.8 seconds of arc.

Neptune

Neptune lies in southeastern Ophiuchus and is considerably more

Clockwise from top left: Comet Bradfield by Daniel Gray, lunar crater Theophilus by Harald Schenk, Venus prismatically refracted in Earth's atmosphere by Norman Happe, the Sun (November 8, 1980) by A.W. Steinbrecher, M-17 — the Omega Nebula — in Sagittarius by Ben Mayer. (Turn to page 82 for this month's Best Astro-Photo.)

planetary data april 1981


LYR
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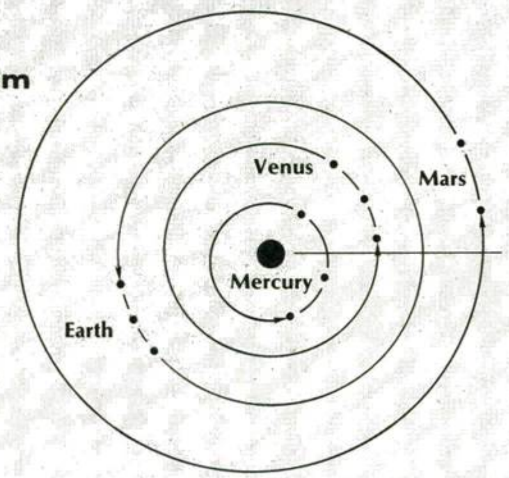
inner solar system


Venus
Mars
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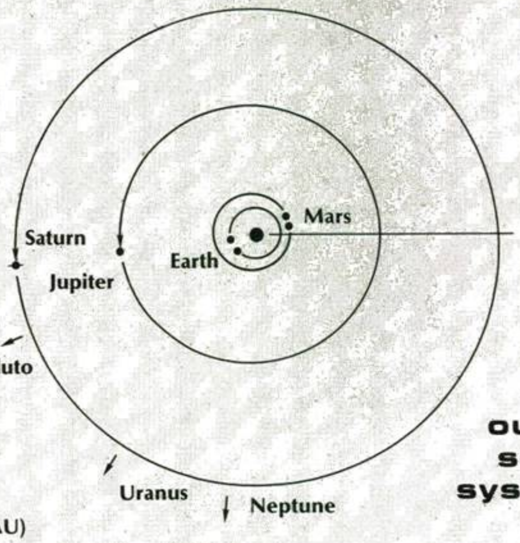
Earth


Mars
Saturn
Earth
Jupiter
Pluto
Uranus
Neptune

outer solar system

				Angular	%	Distance (AU) from:		Longitude:			
		Date	Mag.	Size	Illum.	Earth	Sun	Heliocentric	Ecliptic	R.A. (1981.3)	Dec
Sun		1	-26.7	32.1′	--	1.00	--	--	10°44.5′	0h 41.1m	+4°25.3′
		15	-26.7	31.9′	--	1.00	--	--	24°30.5′	1 32.4	+9°39.3′
		30	-26.7	31.8′	--	1.01	--	--	39°07.6′	2 28.6	+14°40.5′
Mercury	☿	1	0.0	5.9″	75%	1.14	0.45	287°32.2′	347°45.0′	23 20.3	-6°52.0′
		15	-0.7	5.2″	90%	1.29	0.39	335°17.1′	11°23.3′	0 46.4	+2°47.8′
		30	-1.7	5.1″	99%	1.32	0.31	51°07.9′	41°52.6′	2 39.2	+15°36.3′
Venus	♀	10	-3.5	9.7″	100%	1.73	0.72	21°39.6′	20°16.9′	1 18.3	+7°00.3′
		30	-3.4	9.8″	100%	1.72	0.72	53°39.9′	45°00.5′	2 52.5	+15°55.9′
Mars	♂	15	+1.4	3.9″	100%	2.42	1.42	20°18.9′	21°47.8′	1 23.0	+8°09.8′
Jupiter	♃	15	-2.0	43.7″	100%	4.51	5.45	186°59.0′	182°37.0′	12 13.7	+0°14.1′
Saturn	♄	15	+0.8	19.4″	100%	8.61	9.56	187°03.8′	184°34.7′	12 22.6	+0°26.4′
Uranus	⛢	15	+5.7	3.8″	100%	17.97	18.81	237°41.2′	238°52.7′	15 49.1	-19°48.3′
Neptune	♆	15	+7.6	2.5″	100%	29.76	30.28	263°07.5′	264°14.8′	17 37.4	-21°59.3′
Pluto	♇	15	+13.8	--	100%	29.10	30.06	202°58.9′	202°27.9′	13 50.9	+7°33.2′

moon data

New Moon	April 2 at 20:19
First Quarter	April 11 at 11:11
Full Moon	April 19 at 07:59
Last Quarter	April 27 at 10:14
New Moon	May 4 at 04:19
First Quarter	May 10 at 22:22
Perigee: April 5 at 19h	358,498 km
Apogee: April 20 at 16h	406,333 km

universal time

Astronomers the world over use an unambiguous system of time reckoning based on a 24 hour clock, called Universal Time (UT). Times in Through the Eyepiece are UT unless noted otherwise. To convert UT into your local standard time, subtract the following number of hours for each time zone: EST, 5; CST, 6; MST, 7; PST, 8; Alaska and Hawaii, 10. For example, if an event is to happen at 03:00 hours UT on Jan. 2, then the time in EST would be 10 p.m. Jan. 1. Likewise, 03:00 UT on March 5 becomes, in PST, 7 p.m. on March 4.

A little double-exposure trickery let Vladimir Vudler make this stunning image of the Sun in hydrogen light. Using a special filter to isolate the Hα wavelength, he combined a short exposure (1/125 second) that recorded disk detail with a longer one (1/4 second) that captured the dimmer prominences.

difficult to identify than Uranus. The surrounding star fields (close to the plane of the Milky Way) crowd thickly, and Neptune is both smaller in apparent size and dimmer than Uranus.

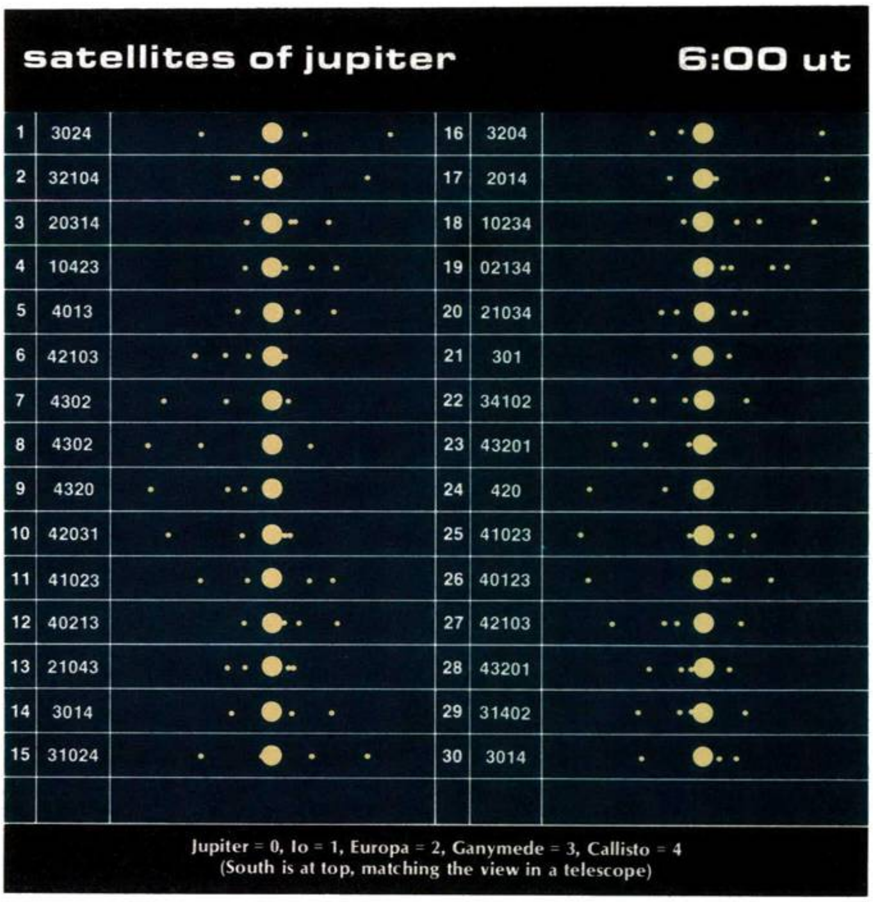
In early April, Neptune will lie about 5′ of arc to the south of a 6.7 magnitude star, SAO 185584. This star, halfway between 52 Ophiuchi and 58 Ophiuchi, lies 18m of right ascension east and 3° of declination north of 3.2 magnitude Theta (θ) Ophiuchi. Neptune has a disk 2.5 arc-seconds across and a magnitude of 7.7.

Pluto

Pluto comes to opposition on April 13. In the 51 years since its discovery, it has completed less than a quarter of one plutonian "year." This dim (magnitude 14) and distant (29 astronomical units away) planet offers a real challenge to find it and follow it. To help you along, use the chart on page 84.

Meteors

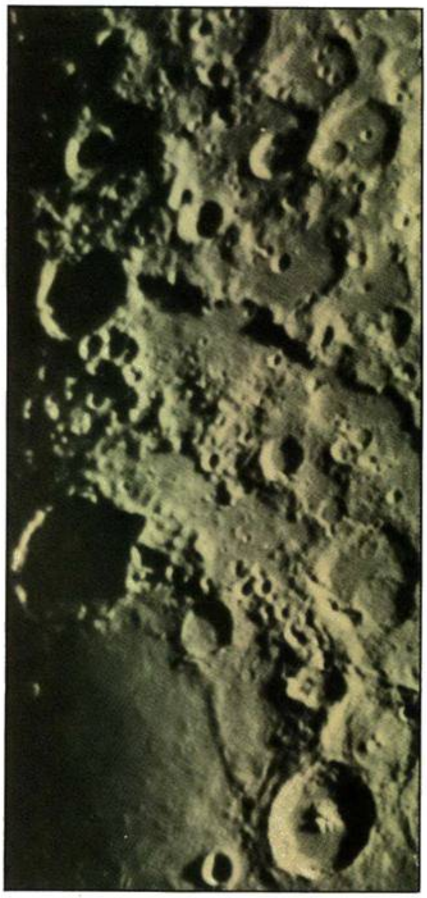
The early morning of April 22 (8h



satellites of jupiter 6:00 ut

1	3024	16	3204
2	32104	17	2014
3	20314	18	10234
4	10423	19	02134
5	4013	20	21034
6	42103	21	301
7	4302	22	34102
8	4302	23	43201
9	4320	24	420
10	42031	25	41023
11	41023	26	40123
12	40213	27	42103
13	21043	28	43201
14	3014	29	31402
15	31024	30	3014

Jupiter = 0, Io = 1, Europa = 2, Ganymede = 3, Callisto = 4
(South is at top, matching the view in a telescope)



Left: Lacking the crisply defined star-clouds of Scutum and Sagittarius, the winter Milky Way seems pallid. Yet how magnificent it is when you can see it all! Jeff Schroeder used a 38 mm lens, 120 film, and a 110-minute exposure to win the "Best Astro-Photo" award for April. Right: western Mare Nectaris, by Jean Dragesco.

UT) is the time of peak activity for the Lyrid meteor shower, a moderately sparse annual display that gives about 10 to 15 bright meteors per hour at best. Their radiant point lies near the Lyra-Hercules border.

You won't see many Lyrids this year: the radiant rises around 8 p.m. local time, but the Moon, three days past Full, rises less than two hours later and will flood the sky with light until sunrise.

observers' reports

From Chuck Coates: Four of us (Eric Greene, John Thomas, Cliff Perkall, and myself) made a visual observation of the Horsehead Nebula in Orion on the evening of January 3. We used my 12½-inch f/5 Newtonian, a 20-mm Erfle eyepiece, and a nebular filter.

The Horsehead appeared as a dark protrusion pointing toward Sigma (σ) Orionis — but keeping that star and another, Zeta (ζ), outside the field of view was a "must." We found that gently thumping the eyepiece made the nebula appear to move and catch our attention. The four of us weren't satisfied with looking until fully an hour had passed. Very rewarding!

close-up on corvus/crater/ eastern hydra

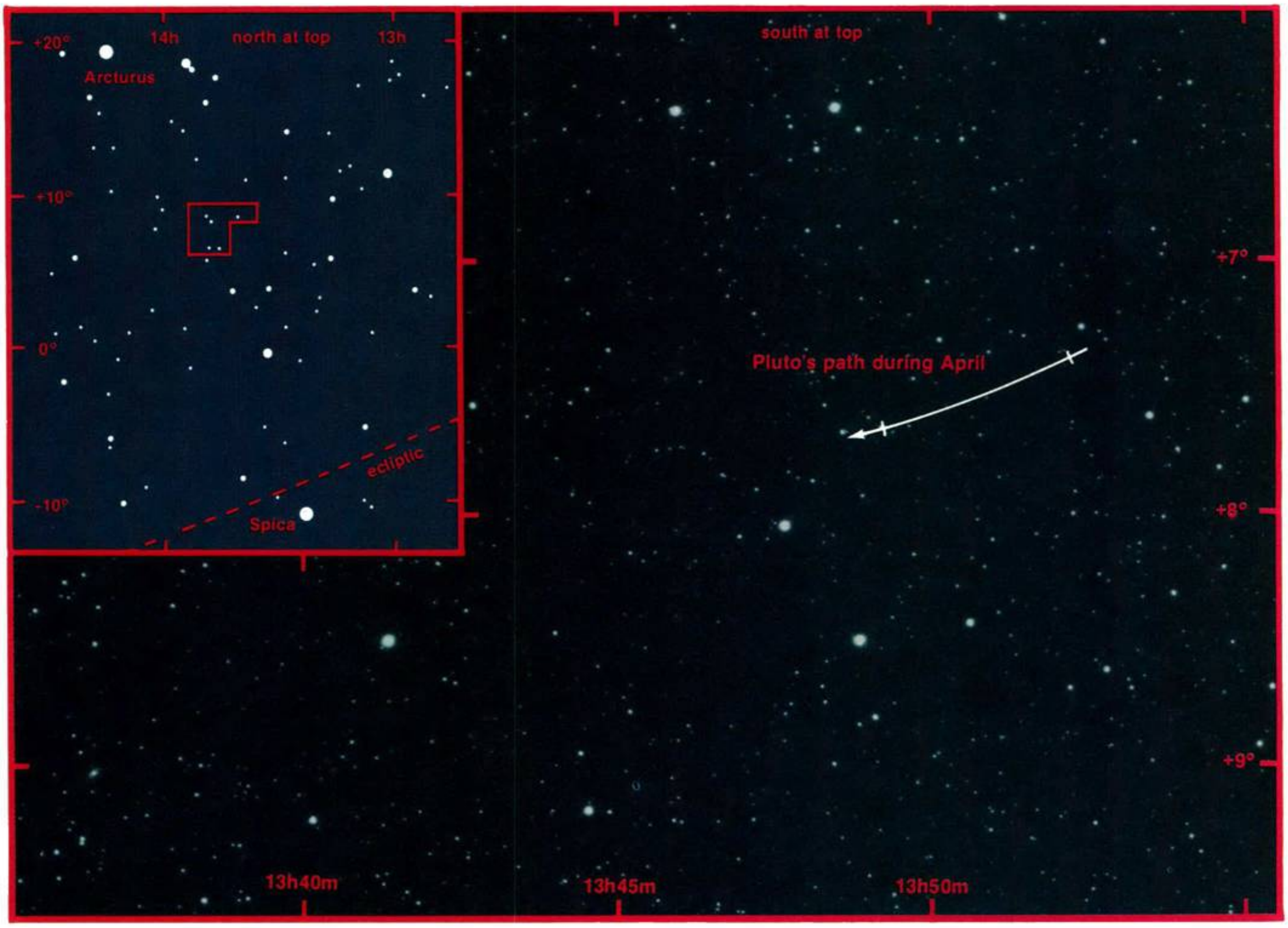
Corvus and Crater are two tiny constellations which appear to be riding on the back of mighty Hydra. You can find them low in the southern sky on April evenings — if you look carefully! Easiest to spot is Corvus, whose four brightest stars (ranging in magnitude from 2.6 to 3.0) form a striking quadrilateral. Crater, though, has little to offer, either to the naked eye or to the telescopic observer. Its two brightest stars are barely fourth magnitude, and it contains virtually no deep-sky objects of interest.

Hydra, on the other hand, is a long, straggling constellation whose eastern portion, included in our region this month, is its richest. Here we find a nice selection of objects, ranging from double stars through galaxies to both a globular cluster and a planetary nebula.

The latter object is **NGC-3242**, perhaps the finest example of its class after the famed Ring Nebula (M-57) in Lyra. Large (40 by 35 seconds of arc) and at ninth magnitude relatively bright, this celestial blue "egg" is obvious in small-aperture instruments at low power. Olcott referred to it as "the ghost of Jupiter," and with its oblate form and eerie blue glow, NGC-3242 does indeed resemble the giant (and far brighter) planet. Look for it by following a line from Gamma (γ) through Alpha (α) Crateris and on about 1⅓ times their separation.

NGC-3923 is an elliptical galaxy found in a sparse region of Hydra just south of the Corvus/Crater boundary. Look for a dim oblong glow a little larger than an arc-minute in extent at about eleventh magnitude.

To relax your eyes after the strain of searching for NGC-3923, center easy-to-find **Delta (δ) Corvi** in the cross hairs of your finder. When you look through your eyepiece, you'll be greeted by a pleasing sight — a third magnitude yellow-white star attended by an eighth magnitude companion of a lilac or reddish-purple hue, a healthy 24 seconds of arc distant. In four-inch and larger telescopes, the dimmer star's unusual color is quite intense, providing a fine contrast with the primary. Although we have no direct evidence of orbital motion, the two stars are moving through space



During April, Pluto will move northwest along the border between Virgo and Bootes. To see Pluto, you'll need at least a 12-inch scope: look for a 13th magnitude dot that slowly shifts its position every night. The map shows stars down to about 14th magnitude. South lies at top. Photo courtesy of Lick Observatory.

together and probably constitute a very long period binary system.

R Corvi, found within the quadrilateral of Corvus, is one of the many long-period red variables scattered over the sky, of which the most famous example is Omicron (o) Ceti — Mira the Wonderful. R Corvi, however, is nowhere near as bright as Mira, attaining only seventh magnitude from its fourteenth magnitude dimmest over a period of 317 days. It is currently fading from its maximum, reached about March 15.

Another long-period red variable in this month's region is **R Hydrae**. Unlike R Corvi, however, R Hydrae sometimes becomes as bright as third magnitude before fading again to naked-eye invisibility. Situated 2½° due east of Gamma (γ) Hydrae, R Hydrae is a fiery red-giant star which pulsates over an average period of about 388 days. It is scheduled to attain maximum light on May 15 of this year, but since its period is somewhat irregular, it bears close watching over the next several weeks.

Sweeping along a line from Delta through Beta (β) Corvi, 4° to the south, a good finder or binoculars will reveal a fuzzy eighth-magnitude glow near a fifth magnitude star. This glow is the globular cluster **M-68**, some three minutes in diameter. Large apertures are necessary to resolve this object into its constituent stars.

S 651 is a pair of well-matched A-type stars separated by 11 seconds of arc in position angle 192°. Although they share a common proper motion, it is not known if these two stars are in fact physically associated with each other.

The large broadside spiral galaxy **M-83** is something of a showpiece within its class, although its extreme southern declination (almost -30°) makes it difficult for most northern observers. Guide stars are scarce here, but you'll find it lurking roughly midway between the stars Gamma Hydrae and Theta (θ) Centauri. In its coded description, the *NGC* gives M-83 a double exclamation mark (!!), which means "remarkable — very much so." Bernhard, Bennett, and Rice noted it as "a triply branched spiral nebula in Hydra. Called by John Herschel very bright, very large. Nuclear condensation near center, and the entire nebula of S-shape backward." Holyoke remarked, "fairly bright and would be easy if it were farther north. At its low altitude during a time of year when hazy skies are frequent, good views are not easy to come by." But many of the classic observers, including Webb and Barns, ignored this beautiful galaxy entirely, and Pickering strangely omitted M-83 from his list of the "best sky objects." Why not take a look at it yourself and see what you think?

Two more double stars, both in Hydra, add an interesting conclusion to this month's selection. Both pairs share a common proper motion, but in neither case has orbital motion been established. **54 Hydrae** consists of fifth and seventh magnitude stars separated by 9″ in position angle 125°. **59 Hydrae** is a pair of perfectly matched sixth magnitude stars, both with white A-type spectra. This double can be considered a test object for large apertures, because the separation between its stars is only 0.7″ (position angle 335°). But the low declination with its consequent atmospheric distortions will make this double doubly difficult! Why not accept the challenge, though, and see if you can split them?

corvus/crater/eastern hydra

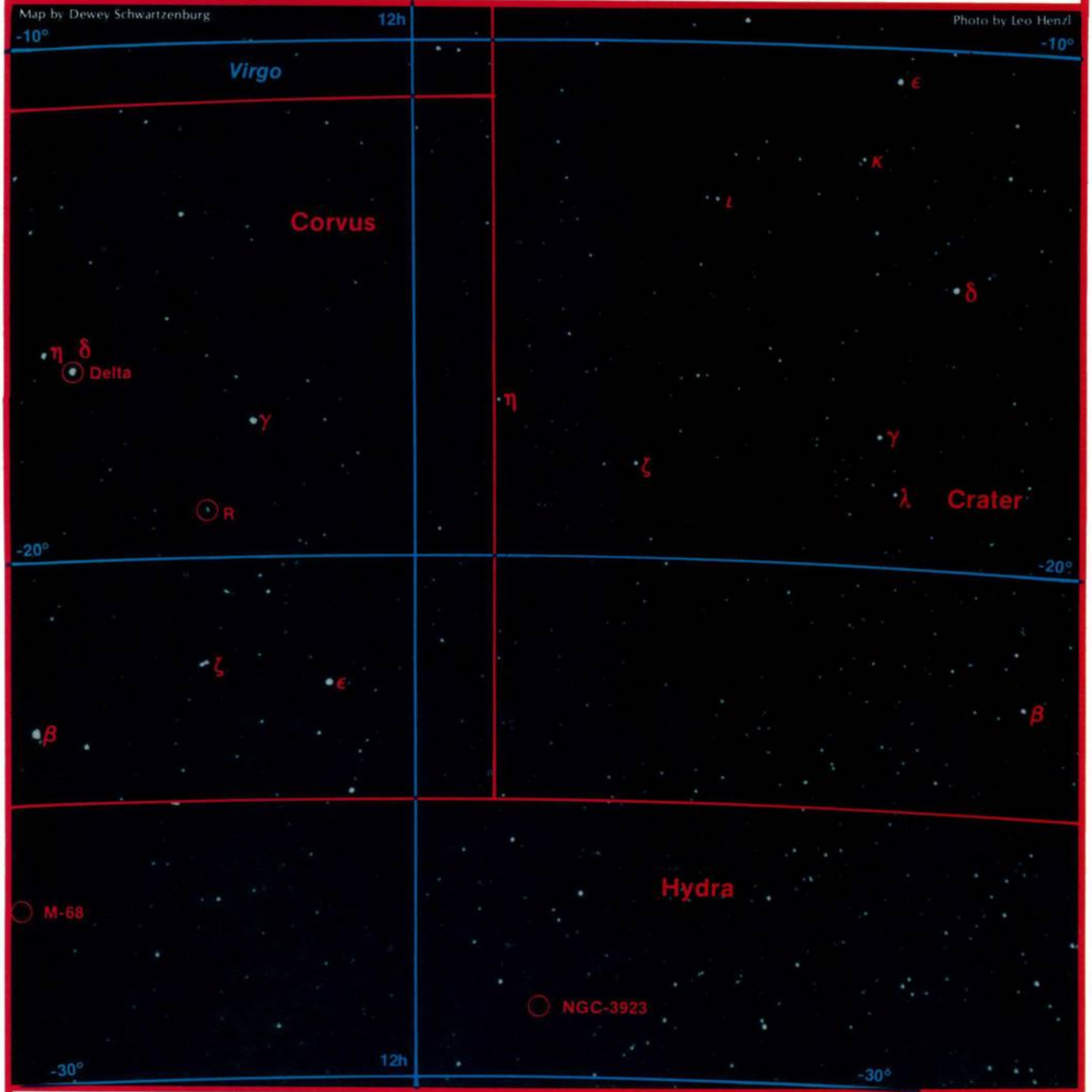
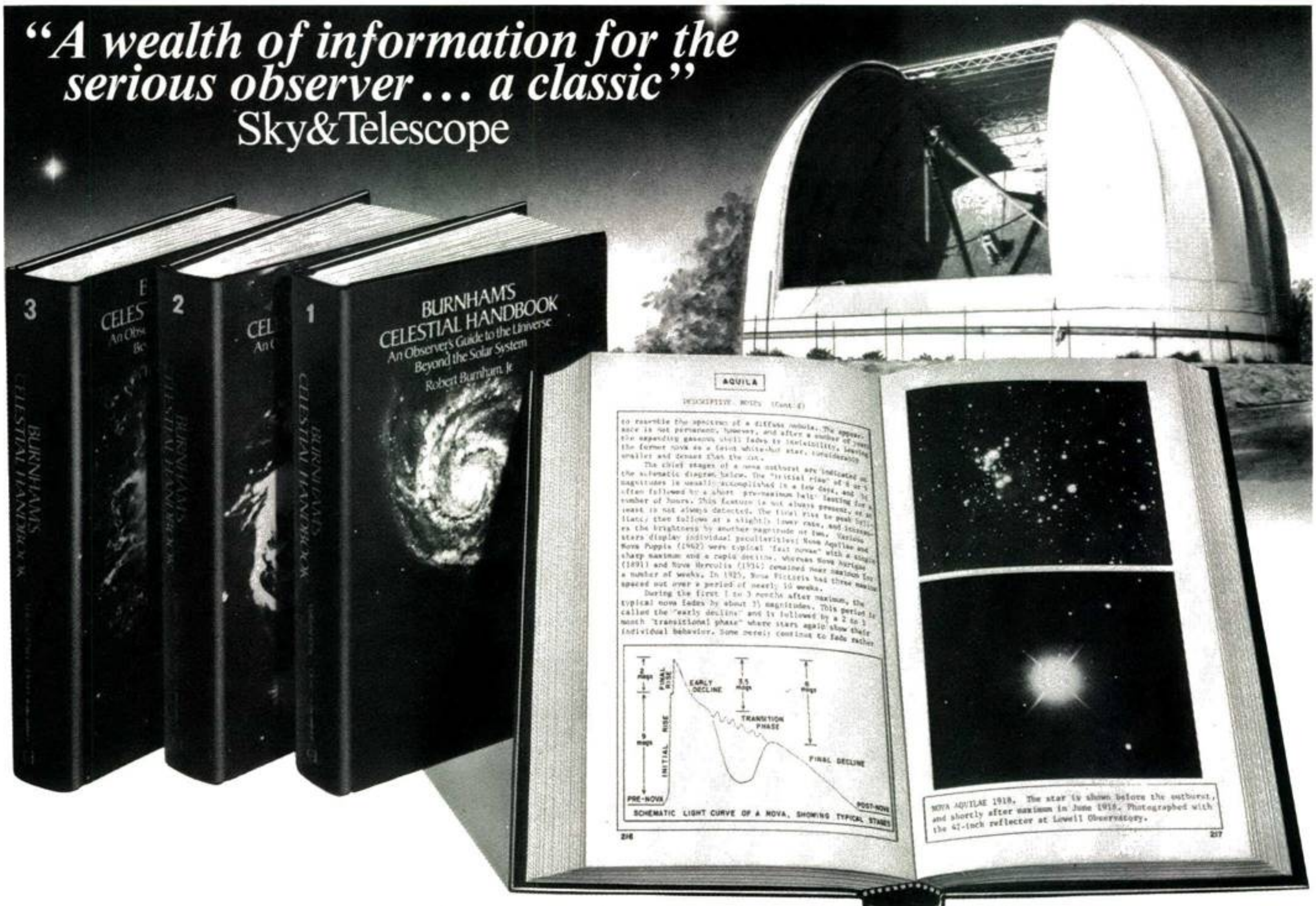

Map by Dewey Schwartzenburg

Photo by Leo Henzl

12h
-10°
-10°
Virgo
ϵ
κ
ι
Corvus
δ
η δ
Delta
γ
η
ζ
γ
R
λ
Crater
-20°
-20°
ζ
ϵ
β
β
Hydra
M-68
NGC-3923
-30°
12h
-30°

Object	Type	Mag.	Size/Sep. Per.	R.A. (1950) Dec.		R.A. (1981) Dec.	
NGC-3242	■	9.0	40″ x 35″	10h22m	-18°23′	10h24m	-18°32′
NGC-3923	§0	11.1	90″ x 70″	11 48	-28°33′	11 50	-28°43′
R Crv	m★	6.7-14	317d	12 17	-18°59′	12 19	-19°09′
Delta (δ) Crv	★²	3.1, 8.4	24″	12 27	-16°14′	12 29	-16°24′
M-68	●	8.2	3′	12 37	-26°29′	12 38	-26°39′
R Hya	m★	3.0-11.0	388d	13 27	-23°01′	13 29	-23°11′
S651	★²	5.5, 7.0	11″	13 34	-26°14′	13 36	-26°23′
M-83	§S	7.5	10′ x 8′	13 34	-29°37′	13 36	-29°46′
54 Hya	★²	5.2, 7.1	9″	14 43	-25°14′	14 45	-25°22′
59 Hya	★²	6.4, 6.4	0.7″	14 56	-27°27′	14 58	-27°34′

★	*Star*
★²	*Double Star*
★³	*Triple Star*
m★	*Regular Variable*
n★	*Irregular Variable*
ʜ★	*Eclipsing Variable*
○	*Open Cluster*
●	*Globular Cluster*
■	*Planetary Nebula*
□	*Bright Diffuse Nebula*
§0	*Elliptical Galaxy*
§S	*Spiral Galaxy*
§ʃ	*Barred Spiral Galaxy*
§#	*Peculiar/Irregular Galaxy*



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NOVA AQUILAE 1918. The star is shown before the outburst, and shortly after maximum in June 1918. Photographed with the 42-inch reflector at Lowell Observatory.
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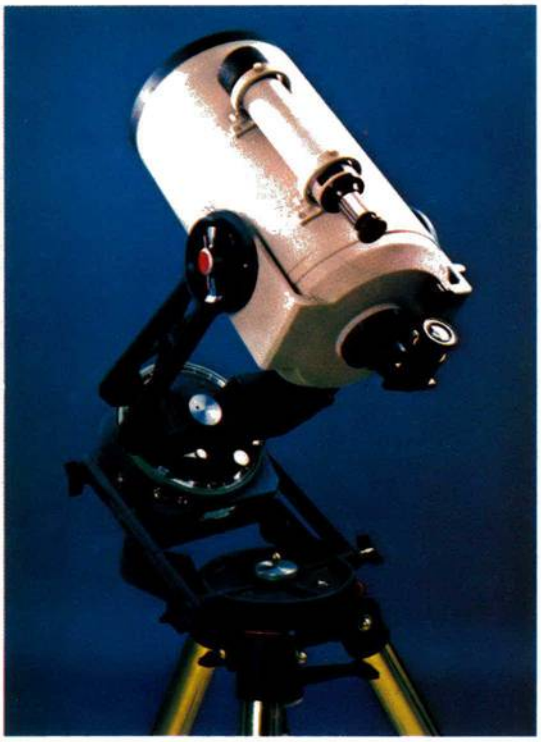
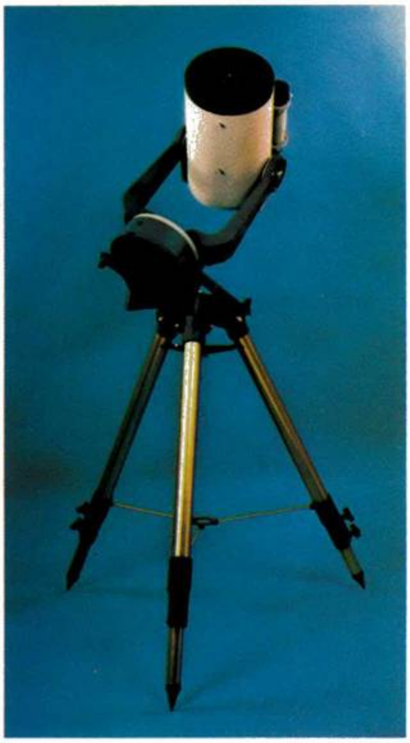


Rear view of the Dynamax 8 mounted on Dynamax Field Tripod



Front view of the Dynamax 8 mounted on field tripod

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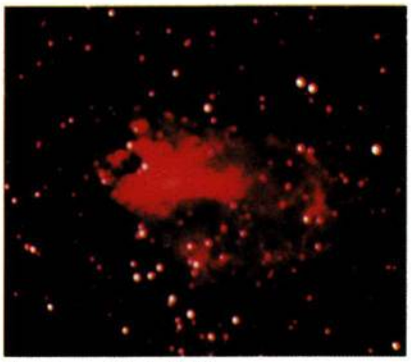

The Omega Nebula (M17) as photographed through the Dynamax 8.

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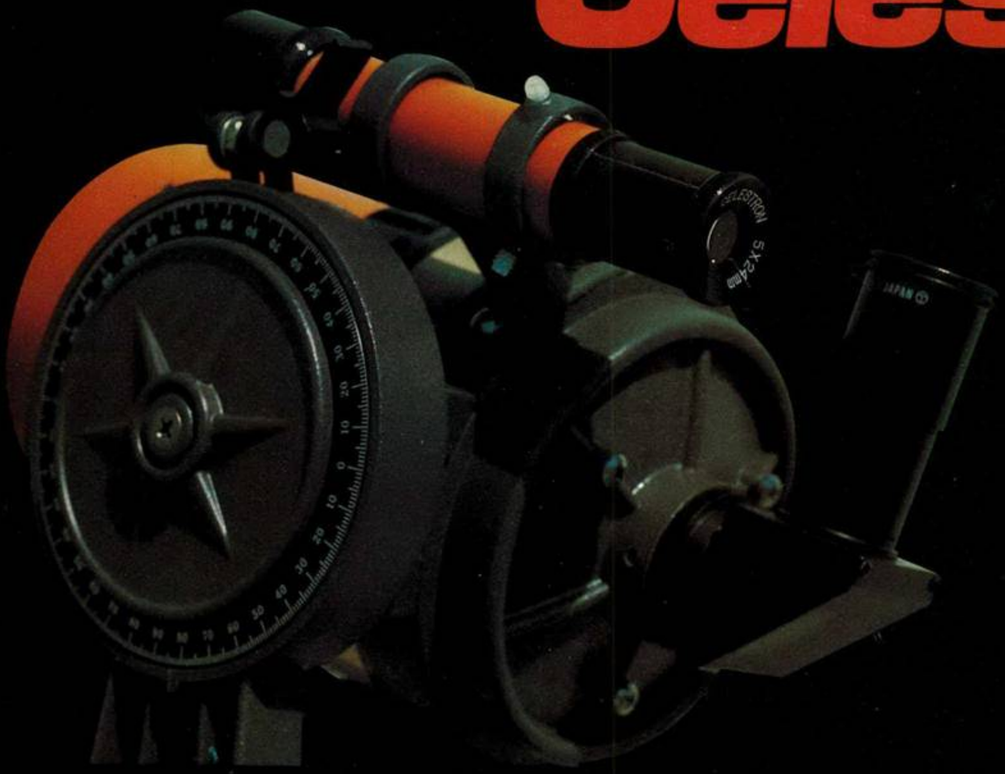

Price Announcement

The following Celestron telescopes will rise in price in the U.S.A. as follows:

	Currently	Effective 4-15-81
C-90 Spotting Scope	$315	$360
C-90 Astro Telescope	$475	$550
C-5 Telescope	$740	$835
C-8 Telescope	$920	$1050

C90 Telephoto Lens

C90 Astro Telescope on Wedge

C90 Spotting Scope

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